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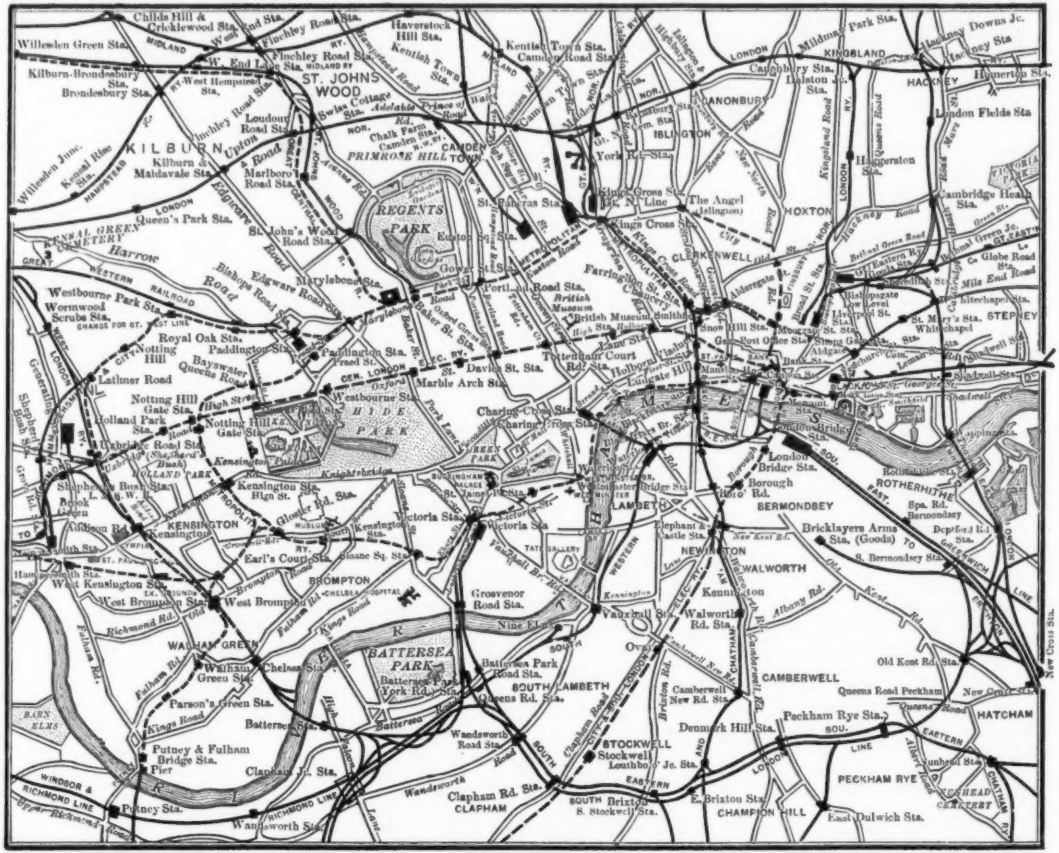


MAP SHOWING THE EXISTING RAILWAYS OF LONDON, SURFACE LINES BEING INDICATED BY SOLID LINES AND UNDERGROUND ROADS BY DOTTED LINES.

THE ENGINEERING MAGAZINE

VOL. XXII. OCTOBER, 1901. NO. 1.

THE RAPID-TRANSIT PROBLEM IN LONDON.

By Frank J. Sprague.

Mr. Sprague's conclusions, presented in this article, are the result of over six months' concentrated study of the problem of rapid transit in London. He brings to it the ability which pioneered electric-tramway development in the United States—for the Richmond road, the first trolley line, was his creation, and on it and about one hundred and fifty more of which he was the promoter are patterned the essentials of the modern trolley system. His system has been introduced on the Chicago South Side, the Brooklyn, and the Boston elevated railways and on the Versailles division of the Western Railway of France. As a leading exponent of rapid-transit electric service, he offers this solution of the greatest and most revolutionary development in city transportation now presented to the world.—THE EDITORS.

WITHIN twelve to fifteen miles of Charing Cross lies an area of 690 square miles, with a resident population of nearly six millions of people. But a little over one-sixth of this area contains three-fourths of this population, say four-and-a-half millions. The number of people who daily enter and leave London is indicated by the fact that there are no less than seventeen main railway stations within a radius of two miles, and fully three hundred local and suburban stations.

The movement of the traffic in the City of London proper, the centre of the financial activity of the world, is suggestive. Although but a square mile in area, with a day population of about three hundred thousand, and a night population of but a tenth of this, in a single day over a million-and-a-quarter of people and one hundred thousand vehicles enter and leave its limits.

The general street traffic is carried on by about 200 miles of tramways, nearly one hundred and fifty lines of omnibuses, and twelve thousand cabs. Internal communication is also provided by two lines of underground railways, with suburban connections, and three deep-level roads operated electrically. Two lines are under construction, six more authorized, and Parliamentary rights are sought by existing or new companies for thirteen railways, or modifications or extensions thereof.

The map facing this page shows the steam and electric roads in operation in the heart of London, and those under construction, authorized or projected, the latter being shown in broken lines. Each of these proposed schemes is promoted on the merits of a particular route, with little regard to any other, and some of them are of doubtful value. In consequence, all new applications were recently referred to an eminent general Parliamentary committee composed of six members each of the House of Lords and House of Commons, which, after three months of inquiry, has referred most of the schemes to select committees, with a report containing certain advisory and mandatory restrictions.

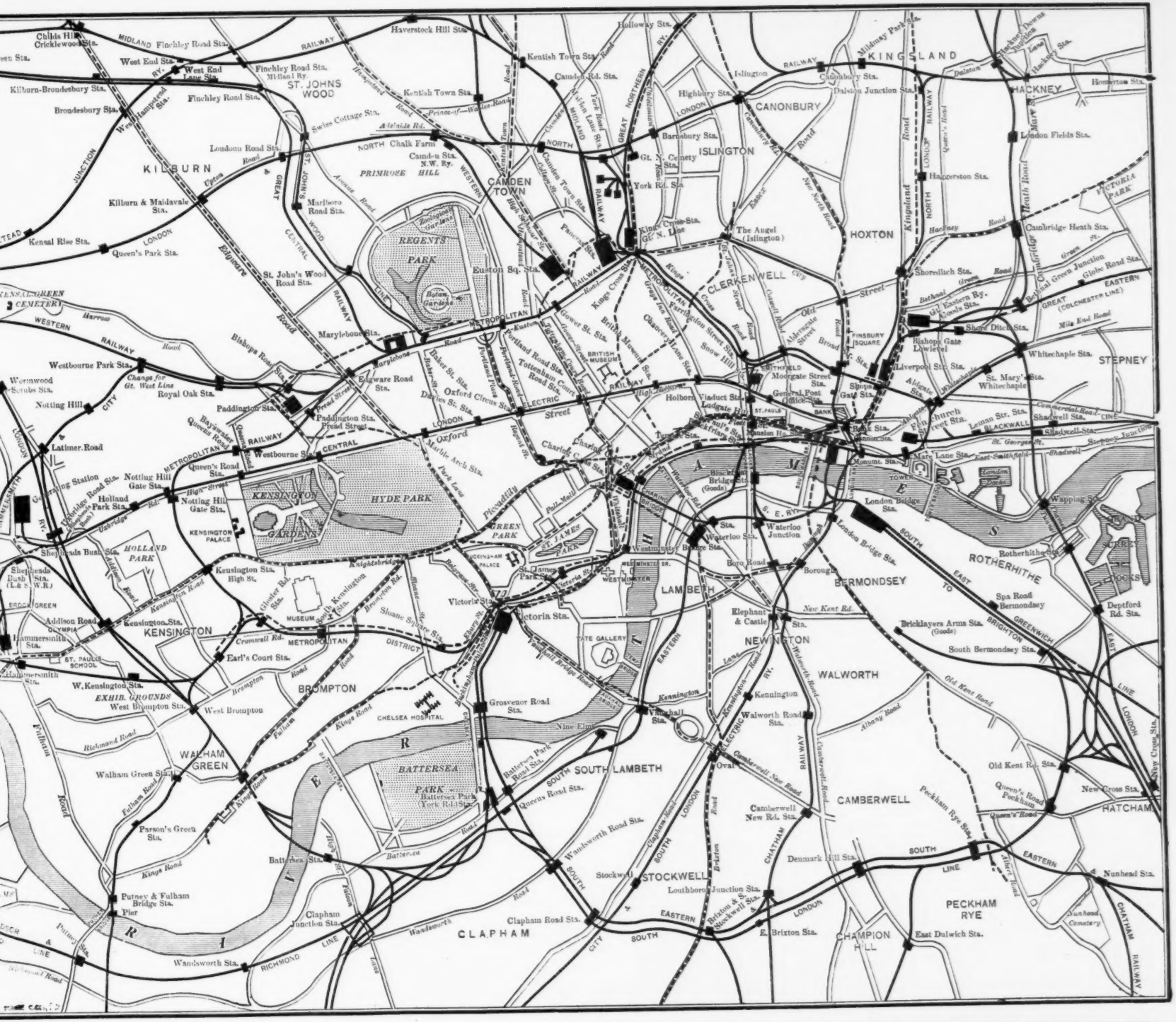
Measured by the needs of London, this report is not entirely satisfying. In brief, it recognizes the necessity of rapid transit; recommends underground roads which can connect with surface tramways and 'busses in outlying districts; suggests that they run from centers of traffic to other like centers, and to the suburban districts; advises shuttle working at the City ends of roads, instead of loops, while permitting them at the outer ends; opposes confluent conjunctions, and congestion of stations; and endorses the multiple motor (unit) system. One of the most important of all questions is but referred to without definite action as being without the terms of reference,—that is, the placing of the whole rapid-transit problem under a permanent board with full power to deal with it in all its aspects, without which no satisfactory solution of the general problem is possible.

Of course, in dealing with this subject, existing conditions must first be considered. Most important of the existing roads for internal traffic, and admitting of the greatest possibilities, are the existing Metropolitan and the District Railways, with their extensions, for they hold the key to any immediate improvement in the rapid-transit situation in London. They may be described as composed of an Inner Circle (or ellipse) about 13 miles around, with branches radiating and looping in various directions. The stations average half-a-mile apart.

Unlike the roads of later construction, they are of the "cut and

Willesden Green Sta.
Kilburn-Brou
Willesden Junc.
HAMPSTEAD
Kensal
GREAT
WESTE
Wormwood Scrubs Sta.
Notti
LONDON
HAMMERSMITH
Shepherds Bush Sta.
Shepherds Bush Sta. (L. & S.W.R.)
Hammersmith Sta.
Fulham
BARNES
WINDSOR
RICHMOND
LINE

MAP OF LONDO


KILBURN
ST. JOHNS WOOD
CAMDEN TOWN
PRIMROSE HILL
REGENTS PARK
ISLINGTON
CANONBURY
HOXTON
HACKNEY
KINGSLAND
CLERKENWELL
STEPNEY
KENSINGTON
HYDE PARK
KENSINGTON GARDENS
HOLLAND PARK
BRIDGE
LAMBETH
BERMONDSEY
ROTHERHITHE
NEWINGTON
WALWORTH
BRIXTON
CAMBERWELL
PECKHAM RYE
HATCHAM
BRIXTON
STOCKWELL
SOUTH LAMBETH
BRIXTON
BRIXTON
BRIXTON

cover" type, brick-arched, and with flat road beds. Built at a cost, in parts, of nearly a million sterling per mile of line, they represent franchises and occupy rights of way which cannot be duplicated. They connect almost every important railway terminal, and many centers of business activity. They are close to the surface of the street, and the stations are roomy and easily accessible. The traffic rails are in a common tunnel which is frequently connected to the open, and can be perfectly ventilated. This tunnel is large enough to take any type of standard car, and to permit of any kind of equipment.

Although planned for connecting the terminals of existing railways, as well as for local transit, the original scheme has been largely subordinated, for the Inner Circle is now a common trunk line over which are run not only Circle trains, but trains from outlying roads. These railways, therefore, now present one of the strangest anomalies of railway operation, for while each owns *in toto* a part of the Circle, and jointly a connecting link, each runs Circle trains in one direction only on one track, trains from outlying sections over both tracks, and each must provide way for trains of other companies.

At present, they are unfortunately under separate managements, as well as subject to running rights which interfere with a reasonable schedule. The class system and compartment cars characteristic of long-distance lines are maintained, while fares vary materially, and in many instances are almost prohibitive. The present operation is a travesty on rapid transit. The Inner Circle presents a ten-minute service between the upper and lower halves, while with stations half-a-mile apart, and with no grades or curves worth mentioning, a schedule of only 11½ miles an hour is maintained. The atmosphere is foul from the use of steam and the accumulations in the tunnels. The station waits are double what are necessary, and the delays are augmented by changing of engines.

Recently, after many years of abuse, and only after being driven to it by the great loss caused by the competitive operation of the Central London Railway, which bisects the Inner Circle, a serious move is being made to equip the tunnels, and later the outlying lines, with electricity. The equipment is temporarily delayed by disagreement between the two roads as to the proper system to adopt, which by the time this article goes to press will probably have been decided, as provided in a recent bill, by arbitration.

The eventual natural solution of the problem, so far as these roads are concerned, is their operation under one management, the abandonment of running rights of other roads over the Circle tracks, and

equipment with a system which permits of the highest practical schedule, and trains varying in length and frequency according to service requirements. The circle should be an exclusive highway, not a trunk stem for several railways, especially unless these are similarly equipped. The joint operation of steam and electric trains in the tunnel is of course not permissible, and until electric equipment is adopted on the branches there must necessarily be a delay of either passengers or trains at junction points. The needs of the traveling public as a whole will be much better met by a high-speed two-minute service on the Circle, with interchange of traffic at junction points, than by a ten-minute service, mixed with half-a-dozen outlying services which must in turn be also subordinated to the exigencies of local traffic.

The three deep-level roads, the City and South London, the Waterloo and City, and the Central London, built to relieve in some measure specific cases of congestion, and to provide for more direct means of communication with the City, are of the tubular type, as are all of the proposed railways. They are driven through the London clay, are constructed with separate tunnels for each line of way, with station gradients, and follow existing streets. The shells of the tunnel are built up of iron rings bolted together, and grouted on the outside with cement under pressure. The depth below the streets varies from 40 to 150 feet, so that in addition to stairways there are provided lifts of great capacity. On the Central London Railway alone there are forty-eight of these, which have carried over 400,000 passengers in one day. The roads are of standard gauge, but the diameters of the tunnels vary from 10 feet 6 inches to 16 feet, the latter being the only one which can take a standard car.

All afford splendid examples of civil engineering and construction, and the general features of the Central London in particular have been worked out with remarkable care and detail. The electrical equipment for the rolling stock on none of these roads, however, is in accord with the latest accepted developments in electric traction, which are contrary to locomotive practice and fixed make-up of trains. The disadvantages of this practice are particularly felt on the Central London because of the impracticability of reducing train intervals; and for the purpose of increasing frequency and getting more traffic, this road recently applied for authority to extend its tracks by loops at each end. The Parliamentary committee has expressed itself as opposed to such extension at the City end, because of the number of roads having City terminals and the probability of the multiple-unit system being the preferable one in the future.

Much has been said on the subject of vibration, because of complaints in connection with the operation of the Central London Railway, and an eminent committee has been appointed by authority of Parliament to consider the cause and its remedy. Both seem clear. The trains on this road are pulled by electric locomotives weighing 45 tons, equipped with four gearless non-spring-borne motors. Rails of shallow section are carried on longitudinal stringers laid in cement to distribute the load over several of the tube sections, and hence transmit any blow directly to the shell. The concentration of weight and the hammer-blow delivered by the motors and trucks, without intervention of springs, seem ample reason for any possible complaints, which, however, are somewhat exaggerated. If instead of this equipment the train were made up of two four-car units under suitable control, each unit having a pair of motors at each end mounted in the usual fashion, then with the weight reduced, distributed, and in part spring-borne, vibration would be practically destroyed.

Deep-level roads must be generally considered apart from the standard railways which enter London, although vital in any scheme of transit. As at present projected they are limited routes between centers or along routes of congested traffic, and means for interchange of traffic between the terminals of the great railways and centers of business, or they may constitute trunk arteries to supply tramways radiating from outer terminals. Having but two tracks, they must always be excluded from express service. Tubular railways are, however, probably the only ones which will be constructed in London, because vested interests and the enormous cost make almost impracticable the construction of additional surface, overhead, or shallow-tunnel lines, although if London could be brought to entertain any such radical treatment of the problem as New York has done, shallow tunnels after the plan of those now under construction there and in Paris would be advisable in some streets. But any road should be authorized only as a part of a well-planned general scheme of traffic, under the supervision of a central authority fully alive to London needs.

Such a scheme must be formulated with a full comprehension of the requirements of rapid transit, which is largely the problem of concentrating masses of people in the morning, and distributing them at night, as well as providing quick inter-communication. The existing steam-railway routes are the most natural and available channels for suburban distribution, but they must be supplemented by local railways in the City for general traffic, and by distributing lines outside.

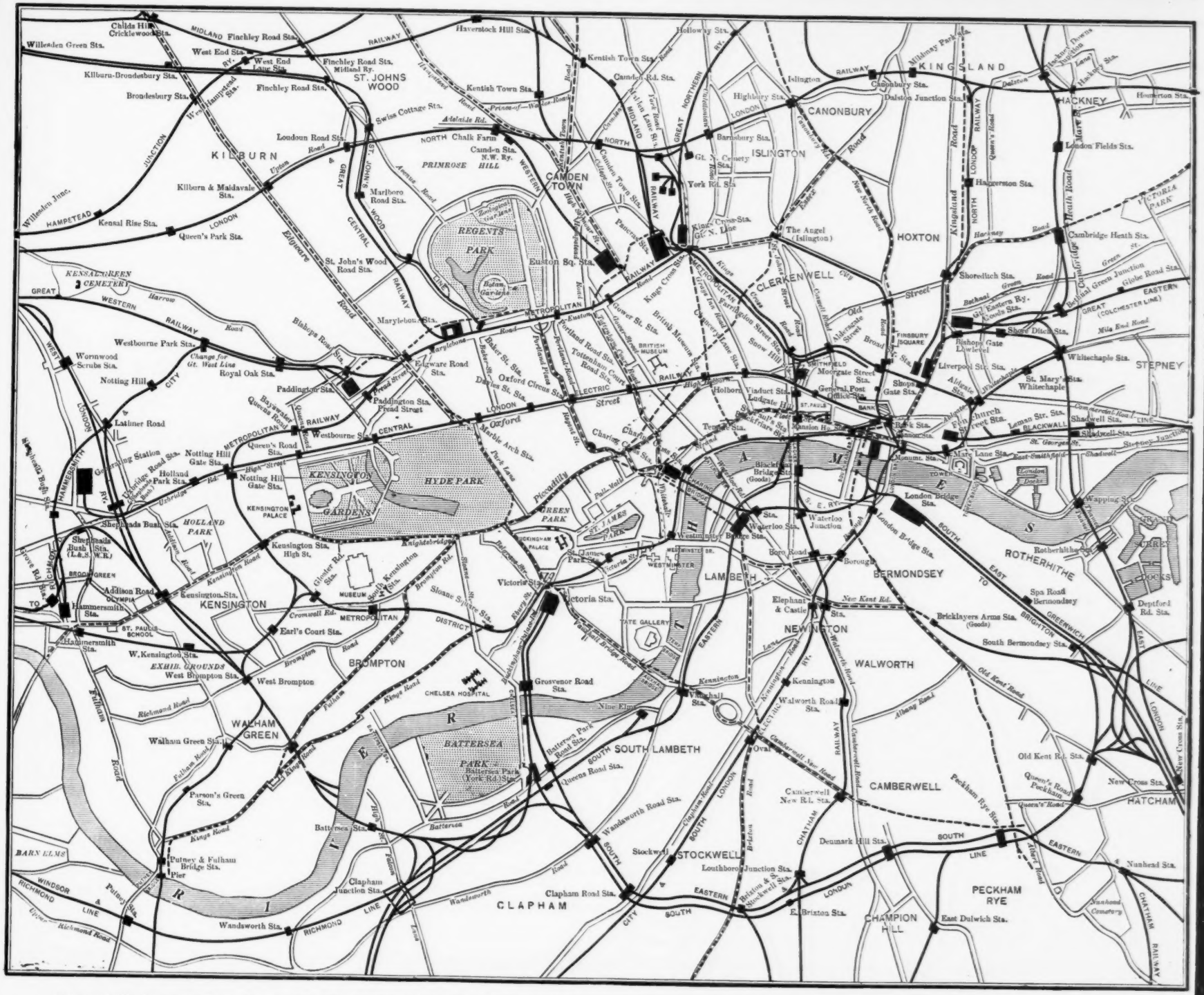
An idea prevails that London conditions simply require transporta-

tion between certain centers of activity. This view must be discarded, isolation of districts destroyed, and London made a city whose people have a common interest, instead of an aggregation of parishes each with local ambitions and responsibilities.

Rapid transit can be had only on reserved rights of way, and be provided by systems which shall offer sufficient return to warrant the construction of new roads, or the supplying of new and suitable equipments on existing railways, whether operated singly or as a part of a general system. Multiplicity of roads, independently promoted, run on limited and oftentimes competitive routes, forming no part of a well-ordered plan, and operated under separate managements, will add to, not solve, the difficulties of the rapid-transit problem.

Every underground railway in London should be operated by a single local corporation, with concentration of management and undivided responsibility, aided by the most advanced methods of equipment and transportation. They should form a network gridironing London, connecting all important centers, the intersections, although at different levels, having common stations, except in the City, and in close contact with the stations of the existing suburban railways. Such a system can, by proper Parliamentary authority, be created by the absorption and harmonizing of the best parts of authorized roads, and the addition of such others as will accomplish the required object without unnecessary duplication of tracks and routes. The general plan having been determined upon, as was recently done in Paris, construction could proceed upon the more important lines, and the less important or new sections be added later.

With well-chosen routes, perpetual franchises, and absence of additional competition, capital will be more readily forthcoming for such a system than it will for an aggregation of independent roads. Since, however, the problem is one vitally concerning all London, it would be preferable to have construction authorized under some plan of municipal help and co-operation, similar to that characterizing the new rapid-transit road in New York, to insure rapid construction, least first cost, and lowest fixed charges. In the accompanying map are indicated some crude suggestions of such a system, which lends itself to flexibility and efficiency of operation and ease of transfer from one branch of the system to another, as well as to connections with existing local and suburban railways. It comprises, with the extensions outside the limits of the map, about 50 miles of line, and could probably be constructed and equipped for less than twenty millions sterling.


Childs Hill & Cricklewood Sta.
Willesden Green Sta.
West End Sta.
West End Lane Sta.
Finchley Road Sta. Midland Ry.
MIDLAND Finchley Road Sta.
Kilburn-Brondesbury Sta.
Brondesbury Sta.
West Hampstead Sta.
Finchley Road Sta.
ST. JOHNS WOOD
Swiss Cottage Sta.
Adelaide Rd.
Loudoun Road Sta.
KILBURN
Kilburn & Maidavale Sta.
Willesden Junc.
HAMPSTEAD
Kensal Rise Sta.
Queen's Park Sta.
LONDON
Marlboro Road Sta.
NORTH Chalk Farm
Camden Sta. N.W. Ry.
PRIMROSE HILL
Haverstock Hill Sta.
Kentish Town Sta.
Camden Rd. Sta.
CAMDEN TOWN
REGENTS PARK
Euston Sq. Sta.
St. John's Wood Road Sta.
KENSAL GREEN CEMETERY
Westbourne Park Sta.
Wornwood Scrubs Sta.
Notting Hill
Royal Oak Sta.
Paddington Sta.
Paddington Sta. Praed Street
Edgware Road Sta.
Marylebone Sta.
Euston
Portland Road Sta.
Oxford Circus Sta.
Baker St. Sta.
Portman Square
Latimer Road
Notting Hill Gate Sta.
Queen's Road Sta.
Westbourne Sta.
Marble Arch Sta.
KENSINGTON GARDENS
HYDE PARK
GREEN PARK
Piccadilly
Oxford
Holland Park Sta.
Shepherd's Bush Sta. (L.&S.W.R.)
HOLLAND PARK
Kensington Sta. High St.
Addison Road Olympia
Kensington Sta.
KENSINGTON
Hammersmith Sta.
ST. PAULS SCHOOL
Earl's Court Sta.
W. Kensington Sta.
EXHIB. GROUNDS
West Brompton Sta.
West Brompton
BROMPTON
Fulham
Richmond Road
WALHAM GREEN
Walham Green Sta.
Parson's Green Sta.
Putney & Fulham Bridge Sta.
Pier
BARN ELMS
Wandsworth Sta.
RICHMOND LINE
Clapham Junction Sta.
Battersea Sta.
Battersea Park (York Rd.) Sta.
BATTERSEA PARK
CHELSEA HOSPITAL
Grosvenor Road Sta.
Victoria Sta.
Victoria St.
Sloane Square Sta.
South Kensington
Knightsbridge
Charing Cross Sta.
Strand
Temple Sta.
Holborn Viaduct Sta.
Ludgate Hill
Mansion House
Cannon St.
Blackfriars Bridge (Goods)
Waterloo Junction
Waterloo Sta.
Waterloo Bridge Sta.
Westminster Bridge
Westminster
St. James Park
Victoria
Borough
London Bridge Sta.
Elephant & Castle Sta.
NEWINGTON
LAMBETH
Vauxhall Sta.
Nine Elms
Kennington
Walworth Road Sta.
WALWORTH
Oval
SOUTH LAMBETH
Queens Road Sta.
Wandsworth Road Sta.
Clapham Road Sta.
CLAPHAM
STOCKWELL
Stockwell
Loughboro' Junction Sta.
Brixton & Stockwell Sta.
E. Brixton Sta.
CHAMPION HILL
East Dulwich Sta.
PECKHAM RYE
Denmark Hill Sta.
CAMBERWELL
Camberwell New Rd. Sta.
Peckham Rye Sta.
Queen's Road Peckham
Old Kent Rd. Sta.
New Cross Sta.
HATCHAM
Nunhead Sta.
Nunhead Cemetery
BERMONDSEY
Bricklayers Arms Sta. (Goods)
South Bermondsey Sta.
Spa Road Bermondsey
Deptford Rd. Sta.
ROTHERHITHE
Rotherhithe
Wapping Sta.
Shadwell Sta.
Stepney Junction
Leman Str. Sta.
Commercial Road
Mark Lane Sta.
Monument Sta.
Tower
London Docks
East Smithfield
St. George's
Aldgate Sta.
Aldgate

Willesden Green Sta.
Willesden Junc.
HAMPSTEAD
GREAT
WEST
Wormwood Scrubs Sta.
LONDON
HAMMERSMITH
Shepherd's Bush Sta. (L. & S. W. R.)
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BARN ELMS
WINDSOR
RICHMOND
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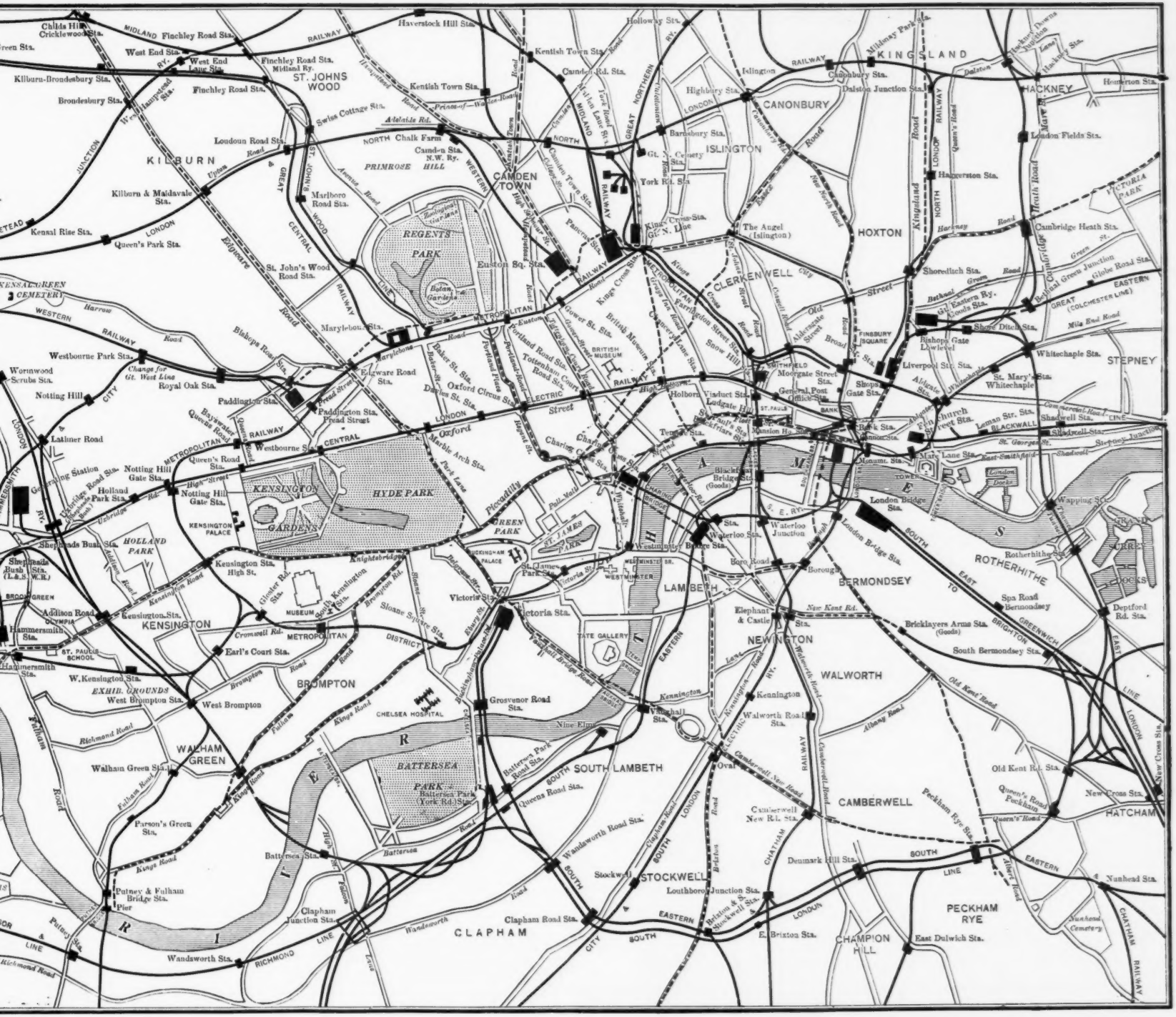
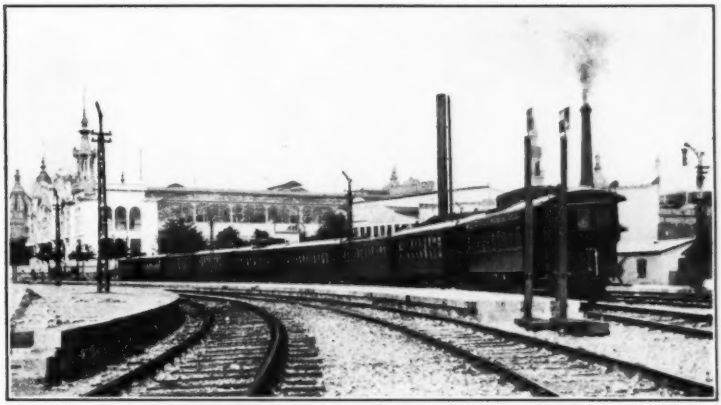
Richmond Road

MAP OF L



MAP OF LONDON, SHOWING IN SOLID LINES THE EXISTING RAILWAYS AND IN BROKEN LINES THE ADDITIONS NEEDED TO COMPLETE A HARMONIOUS COMPREHENSIVE PLAN, AS PROPOSED BY MR. SPRAGUE.

Operation of such a system must be accompanied by radical departures from English steam railway methods. There should be an abolition of classes and differential fares, as well as of the present type of cars. No road operating for internal and short local traffic is justified in having class distinctions; they might as well be made in the waiting stations and platforms, or in the lifts. The experience of the existing deep-level roads, as well as of all American railways of like character, confirms this view. With the abolition of classes will disappear any practical reason for differential fares, for they can be set at a fair price

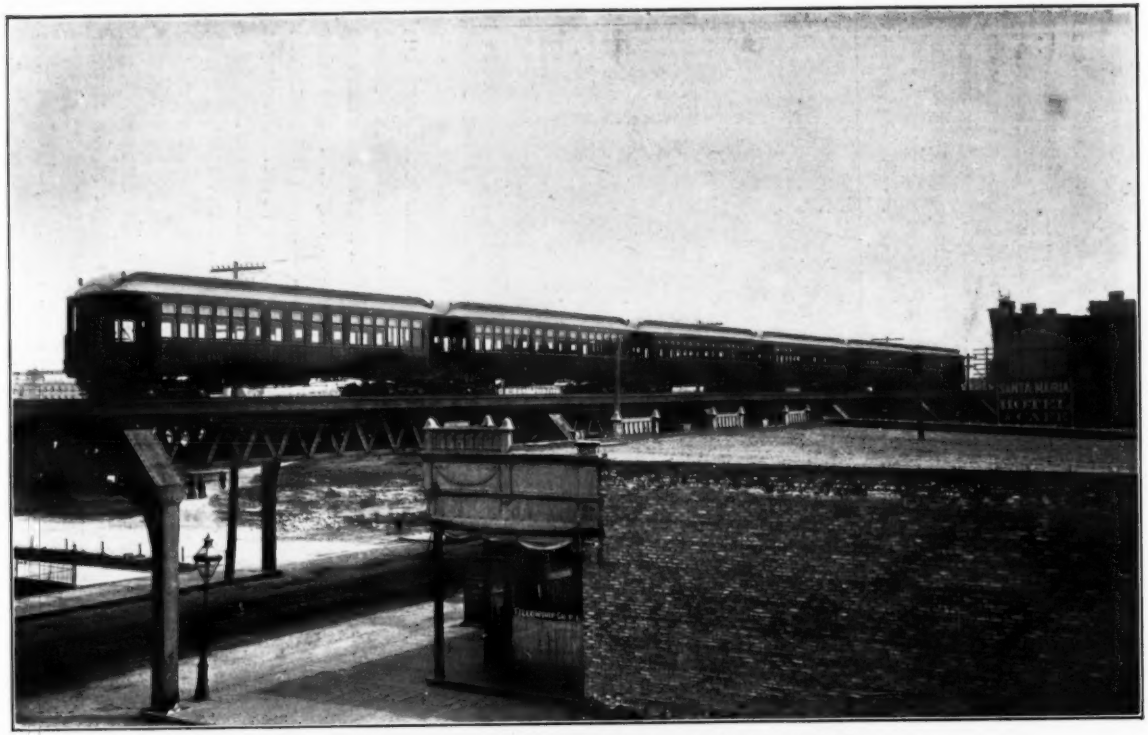


MULTIPLE-UNIT TRAIN, WESTERN RAILWAY OF FRANCE.

for the mean distance traveled, and when so determined return tickets are unnecessary. As a concession to workmen's necessities, a reduced fare may be permissible and advisable at certain hours of the morning and evening, at which times also trains will run very full. For other hours tickets can be sold in bulk at some reduction, for the possession of tickets tends to increase traffic at intermediate hours. On almost all branches there should be free exchange at common stations, save in those cases where it might be necessary to divert or restrict travel, as is done on the Metropolitan Railway of New York, and on the elevated and surface lines in Boston.

The compartment car is unsuited to traffic of this character. While easy to unload, it is not as quickly loaded in practice as the corridor type with free access from one car to another. If train lengths are made to vary with traffic demands, such a car will load and unload more quickly and will run more evenly filled than the compartment type.

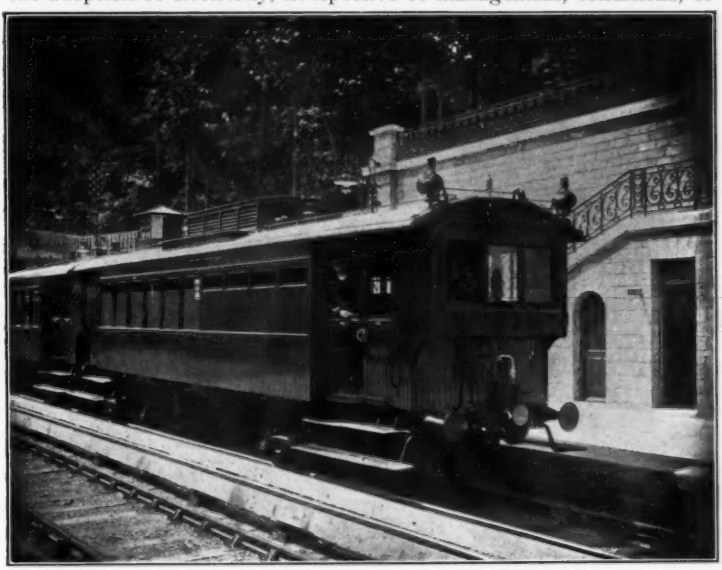
Much has been said about confluent conjunctions, through traffic,



MULTIPLE-UNIT TRAIN, SOUTH SIDE ELEVATED RAILWAY, CHICAGO.

and loops. Grade crossings should, of course, be prohibited, and junctions other than end-on ones should be made only where Y's are required to get necessary car movements, or where trains can be safely diverted. Most branches should be operated on the shuttle principle, and loops even avoided unless they are of considerable size and take in new territory with two or more stations. Where common stations are impracticable, the separate stations should be connected by sub-ways, as is so well done at the City ends of the present deep-level roads.

That electricity shall be the motive power for any rapid-transit road needs no argument. How it shall be applied on roads with congested traffic should be logically apparent, although there is a more or less current notion that the ills of some railways can be cured simply by the adoption of electricity, irrespective of management, conditions, or



LEADING END OF NINE-CAR MULTIPLE-UNIT TRAIN ON THE WESTERN RAILWAY OF FRANCE.

methods, and that the crowded condition of others can only be relieved by the construction of parallel lines either overhead or underground. Both conceptions are erroneous. The underground roads are competitive with surface facilities, and where there is competition that route will command the most passengers which can offer the easiest access, the greatest convenience and comfort, the lowest fares, and the

most frequent and rapid service. The latter can be had only by a special application of electricity.

A railroad consists of two parts: first, the stations, tunnel, permanent way and rolling stock; and second, its motive-power equipment. The initial cost of all that is included under the first, which may be considered "dead" equipment, varies from about £400,000 per mile of line (double tunnel), on the tubular railways, to nearly £1,000,000 per mile on a part of the older tunnels. All the roads normally provide for only two tracks with the necessary sidings and cross-overs.

MULTIPLE-UNIT TRAIN, BOSTON ELEVATED RAILWAY.
Showing station building, grade, and curve.

The tremendous cost of this part of any road which can be constructed in London prohibits general consideration of the duplication of tracks on roads which depend upon local traffic. It is advisable and necessary, therefore, to make the greatest use of the unavoidably large fixed investment by the adoption of a type of electrical equipment which shall permit of any increase of traffic up to the physical limitations of the road.

Railroading is, after all, the problem of getting traffic, and transporting all that can be got quickly and safely at a minimum cost. Oftentimes, from an over-zealous regard for operating expenses, a manager loses sight of what induces travel. There are two classes of traffic—one forced, and the other coaxed. The latter is generally needed to fill trains at light hours, and is competitive. The most

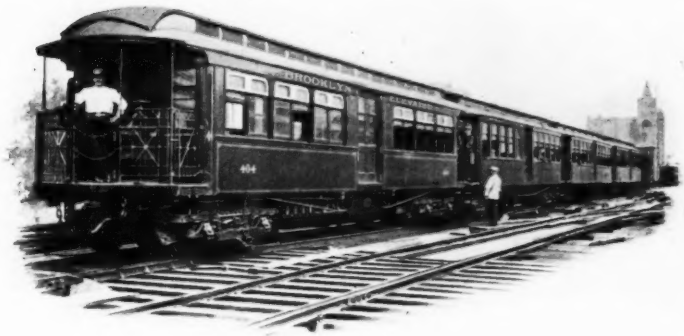
SULLIVAN SQUARE TERMINAL YARDS AND SHOPS, BOSTON (MASS.) ELEVATED-RAILWAY SYSTEM.

cogent appeal to this class of passengers is promptness and speed of service, as well as comfort. The ideal service, so far as the passenger alone is concerned, would be by single cars operated at high speeds, and following each other at the shortest possible intervals. The conditions of tunnel service, however, and the heavy character of the traffic at certain hours prohibit this ideal condition. So there must be, to get the most practical results, an expansion of the car into a train varying in length according to the time of day, and a lengthening of intervals to meet the requirements of operation at high speed.

High speed requires large power, this depending on the frequency of stops and the character of grades and curves. To utilize it there must be a high percentage of weight on the drivers. This weight may be especially created, as with a locomotive or locomotive car, or it may be provided largely by the car-bodies and passengers, as on an ordinary tramway, where all or nearly all the weight is on the drivers.

These requirements and the consideration of many practical features of railroading in handling frequent trains and a congested service have led to a natural and logical development in modern electric traction, now generally known as the "multiple-unit system." This is a method of train operation and control by means of which cars are equipped with motors and motor-controllers individual to these cars, so that they may be united with any number of other cars similarly equipped, or with any number which have no motors, into a train of any length, and operated from as many points as desired through a controlling line common to all cars. The number of the cars, their sequence, and their end-to-end relation are preferably matters of indifference. The character and capacity of the equipment is dependent upon the schedule required; it varies from every car, where the highest schedule is required, down to two cars in a train. Every motor car is a unit, and any combination of motor cars and trail cars may also be considered a unit, which can be operated from either end, and can be joined with other units.

Such a system readily lends itself to every condition of congested service. The similarity of equipment insures flexibility of train operation, and provides a motive power proportioned to the requirements. Locomotive switching operations are abolished, trains can be reversed at any cross-over, and traffic concentrated on any section of a road. The safe interval between trains is dependent upon the maximum speed and the power of control, and hence both the time and the distance intervals between trains can be reduced. A motorman will approach a station with more confidence, and under closer headway, when



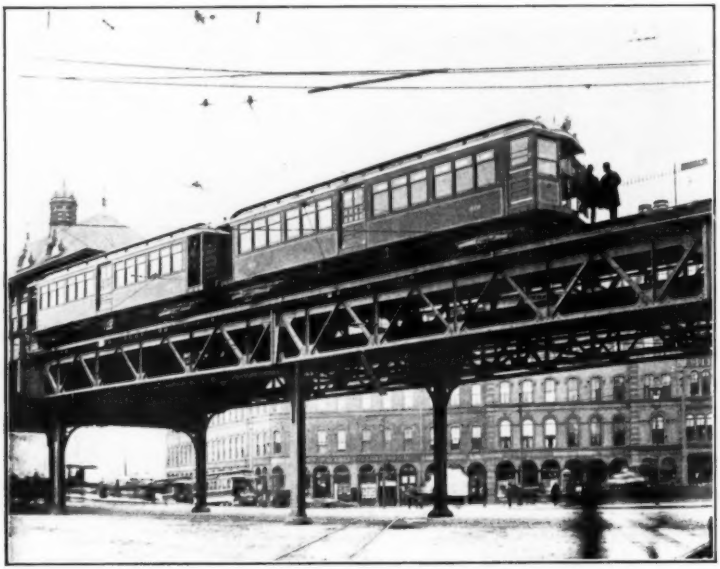
MULTIPLE-UNIT TRAIN, BROOKLYN ELEVATED RAILWAY.

his maximum speeds are low and the braking distance traveled short, and when he has confidence that the train ahead, once started, will promptly get away. With high-powered equipments any required schedule up to the maximum becomes possible, and with any given mileage the number of cars in service can be made a minimum. Where a crowded system has main tracks with branches, units for the different branches can be combined on the main line, and split up at junctions, and *vice versa.*

The operation of the multiple-unit system is the simplest. Every unit being self-contained, and every aggregation of such being, so far as the motorman is concerned, simply an extension in the length of the unit without in any manner changing its character, operation becomes habit. Like hand and like train movements exist whatever the combination of units. Protected by automatic features, a man of even limited intelligence can handle trains with less trouble, so far as the electrical apparatus is concerned, and with less instruction than is required for the air brake, for apparatus is now actually built on the plan of making it "fool-proof and fire-proof." The highest safety being essential, the system of operation obviously provides it. In case of failure of brakes, or on slippery rails, the machines throughout the entire train can be safely reversed. The current input to the machines is automatically limited on each one to its safe capacity. In case an accident should happen to an operator, the entire power is instantly removed from the train, and in case the master switch on the leading car be-

comes disabled the train can be operated from either end of any other car. In fogs and on slippery rails, a fixed schedule can be maintained more effectively because of the lower maximum speed and the less distance traveled in braking.

Although no regular testimony was taken before the Parliamentary committee on the subject of train equipment, many of the advantages stated were so apparent that, reinforced by the facts concerning the operation of the Chicago South Side Elevated Railway, where the multiple-unit system was first put into public operation by the writer, and by those relating to other roads since equipped, the system practically received the endorsement of that committee, a fact which may have a potent and far-reaching influence.



TWO-CAR MULTIPLE-UNIT TRAIN ON THE BOSTON ELEVATED RAILWAY.

The system also has the endorsement of proved commercial success. Within four years it has been put in operation on, or contracts have been closed for, over two thousand one hundred full-sized railway cars, requiring equipments aggregating 275,000 horse power, or more than is on all the electric railways of any character in Great Britain, and its adoption is already determined for at least seven hundred cars more, requiring 160,000 horse power.

In practice, train lengths vary from two to nine cars, and equipments from an average of 100 to 300 horse power per car, the latter characterizing the Boston, Mass., Elevated Railway, the latest road equipped. This is the most difficult and the highest-powered regular railway in existence, and operates the heaviest passenger service per mile and per car. It has descending grades of one in twelve, ascending grades of one in twenty, a succession of sharp and reversed curves, a possibility of twenty routes in 7 miles of line, and every car on every train is equipped with two 150-horse-power motors. It opened June 10, 1901, carrying 300,000 people with but sixty-six cars in operation, it has since regularly carried 200,000 people with ninety cars in service, and within a month after opening it has been found necessary to increase its equipment from one hundred to one hundred and fifty cars.

Roads of standard clearance permit of the fullest application of this system, although on the Metropolitan and District Railways the requirements of even an excellent schedule demand the equipment of only half of the cars with two motors of proper size each. Any road of tubular construction having 13 feet diameter likewise permits of the application of the system to any extent. Where the diameter is only 11 feet 6 inches, however, as on some of the roads built or projected, then there can be but limited equipments. These roads are built with accellerating and braking gradients, so that good schedules require but two motors on half the cars. By having trains made up of two three-car, or two four-car units, the first and last car of each unit being equipped with two motors, a special construction of car under even these limited dimensions becomes possible. On such equipments the best practice is to cut the trains in two for the lighter hours of service, and to maintain a high frequency, alternate trains being sent unbroken into the yards.

With tunnels of the proper size, it is evident that on the multiple-unit plan a general system can be operated with the minimum of equipment and the most economical distribution of cars, trains can be made of varying lengths on different sections and branches to best accommodate traffic and to prevent massing of passengers, and they can be handled in the most expeditious and efficient manner with the minimum of trackage.

Space permits only limited reference to the suburban steam lines, which, however, are vital factors in the general problem, and which as yet have no realization of the disastrous effects of a live trolley competition. At certain hours of the day some of these have already nearly reached the limit of expansion by steam operation on existing tracks,

and are seriously considering adding to their facilities by construction of tunnels for their suburban lines. Such construction is at present utterly unnecessary, and if these roads should operate their suburban traffic electrically, the trains at times of heaviest traffic being made up of two or three units, each having power enough to operate it at a proper schedule, the capacity of these roads could be very largely increased. On many of them there are from eleven to thirteen cars in a train, even at times of light traffic, when the trains are often an hour apart. With station distances averaging 1¼ miles, the schedule speed is sometimes as low as 13 miles per hour. On such roads the train movements can not only be greatly increased at busy hours, but a traffic can be created at other hours by offering superior facilities in higher speeds, more frequent trains, and prompt connections with local feeders, which, quite apart from any economies of operation, would insure a large return on the cost of an electrical equipment.

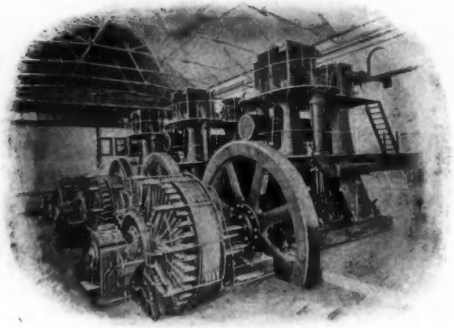
Briefly summarizing then, rapid transit in London and its suburbs depends upon a wide-spread and radical application of electricity, and this is of even more importance than the creation of new tunnels. The latter should be built according to well-matured plans, under a central authority, and form a network following main arteries of traffic and connecting busy centers with other centers, and with outlying districts and suburban stations. The roads should form part of a general system, under a single management and responsibility. Classes should be abolished, one regular rate of fare established, with workmen's fares in limited hours, and there should be free exchange except on limited routes, or within two zones. Locomotive practice should be abolished, and trains operated in small units which could be combined at will. Electric trams should be provided in place of many of the 'bus lines on crowded streets, and radiate from every terminus of tubular railways and from most of the suburban stations. Every steam railway should equip at least its suburban service with electricity on a plan which permits of variable train lengths, plural control, high schedule speeds, and the maximum use of existing trackage.

The electric railway has become a modern necessity, and the greatest of philanthropic agents. It is a distributor of the masses, and the most effective agent in solving the housing problems of a metropolis. Every minute taken from the time of transit to and from business is a minute added to the fireside and home. Every increase of speed adds to available dwelling space, increases taxable areas, augments traffic, and betters the *morale* of the people. The days of doubt and hesitation have long passed. Within thirteen years, in the United States

LEADING END OF MULTIPLE-UNIT TRAIN, BOSTON ELEVATED RAILWAY.

alone, electricity has been adopted on more miles of street, elevated, and suburban track, replacing horse, cable, and steam equipments, than there are miles of steam railway in Great Britain. It needs but a practical survey of all that has been accomplished in this connection to realize the immense benefits possible by an intelligent adoption of electric propulsion.

Last, and not least of considerations at a time when there has been a universal reduction of dividends on English railways, there will be found in a suitable electric application a remedy for many existing ills, and others to come as tramway competition begins to be seriously felt. When English capitalists and transportation managers wake up to the possibilities of electric traction, concerning which there is no longer room for question, there will be a movement whose far-reaching character can at present only be slightly realized, and to which the English traveling public will heartily respond.



THE STANDARDIZATION OF ELECTRICAL APPARATUS.

By J. T. Broderick.

In the following article, Mr. Broderick takes up the discussion of the important opportunities for economy presented by present conditions in the electrical manufacturing trade. The comparative youth of the industry is sufficient explanation of its lack of settled standards; but much of the diversity of detail, dimension, and pattern might be simplified, to the great advantage of both manufacturer and consumer. In this paper the view-point taken is that of the maker. A sequel will show how the user's interests are concerned.—THE EDITORS.

THE standardization of electrical apparatus was carefully considered about two years ago by the American Institute of Electrical Engineers, and preferred potentials and frequencies, as well as methods of dealing with the questions of efficiency, temperature, and insulation, were adopted. The subject, however, is one which concerns not alone the electrical engineer; it is of vital importance to the manufacturer of electrical apparatus, to the mill or mine owner, to the local company producing light and power, and to the public generally. In the following pages it is treated mainly from the standpoint of the manufacturer.

A manufacturer, to be successful, must produce apparatus which is economically designed, which can be supplied when it is wanted, and which will do the work required of it in a satisfactory manner. In

other words, cost, delivery, and quality are the primary factors with which he must deal; and in dealing with these factors standardization must of necessity engage his attention.

In order that whatever is said concerning the cost factor may be wholly intelligible to those unfamiliar with accounts, a brief explanation of how costs are made is perhaps required at the outset. Different methods of calculating costs are employed by different manufacturers; but whatever the method employed, consideration must always be given to three main elements—material, labor, and operating expense. The expenses for material and labor required in the construction of a given machine are easily determined under any thorough system of accounting. The operating expense, which is as much a part of cost as the expense for material or the expense for labor, is usually obtained by means of a percentage added either to the charge for labor or to the total charges for labor and material. The sum of the charges for labor and material and the charge for operating expense, obtained in the manner described, constitutes cost.

The utmost pains are taken in all reputable manufacturing organizations to insure accuracy in this cost; but considering it with reference to any individual machine or appliance, it will be seen that it is a computed cost rather than an absolute one. It would be impossible, with any reasonably simple and economical system of accounting, to apportion the operating expense with strict accuracy over the many types, and the many modifications of these types, which must be handled by even the smallest concern making electrical apparatus.

No manufacturer, therefore, can determine with exactness the effect of needless differentiation and specialization on the cost of his product. Broadly speaking, it is evident that when apparatus is built in large quantities its cost is less than when built in small quantities, and that modifications, not in the direction of improvements in design, increase the cost of apparatus built in either large or small quantities. It is further evident that apparatus which must be newly designed throughout costs more than that which has been developed, the difference in cost, of course, being greater when the developed apparatus is made in large quantities than when it is made in small quantities. A general idea of what specialization means, from the view-point of the manufacturer, may be obtained by an analysis of certain differences in the cost of producing standard and special apparatus.

Assuming the highest practicable degree of productive economy attained in the case of standard machines made in large quantities, and assuming further that in such case the absolute cost of a given machine

is $100, it may be said that the absolute cost of a special machine is increased over and above this amount, because of its being special, for the following reasons:—

First, the cost of the investment required in connection with the manufacture of a special machine is greater and the investment is utilized at a much lower degree of economy. More floor space is required, and the space allotted is needed for a longer period. Special tool fixtures, such as jigs, blocks, cutters, and boring bars, may be needed; or, if standard fixtures are employed, in adapting them for service on special parts they are destroyed or their efficiency for service on standard work is impaired. It is easy to see how specialization affects the economy of tools by conceiving of a machine-shop installation consisting of a milling machine, a drill press, a boring machine, and a grinding machine. These four tools, we will say, are to-day employed on standard work, each one performing its peculiar operation, the drill press taking the work from the milling machine, the boring machine taking it from the drill press, and the grinding machine taking it from the boring machine, with clock-work regularity and continuity and at the highest attainable degree of economy. To-morrow some operation in connection with the manufacture of a special generator or motor requires to be performed. Numerous letters and telegrams have been received urging that its delivery be hastened and that, if necessary, it be given the right of way in production. The drill press, in the group of four machines just described, happens to be the most suitable tool in the plant with which to perform the work; there is nothing to do but to utilize it, and, as a consequence, the milling machine, the boring machine, and the grinding machine, are temporarily thrown out of service. To avoid such a condition, spare facilities for emergency purposes must be provided or overtime work done with the drill press. Either method involves extra expense. No practicable plan has ever been devised by which the extra expense incurred by reason of the additional investment, of the destruction of fixtures or their impairment for use on standard work, and of the reduced efficiency in the utilization of tools, can be wholly included in the cost of a given piece of special apparatus.

Second, the direct labor cost of a special machine is bound to be considerably higher than that of a standard machine. The utmost care being required, this labor must necessarily be done by the most skilful and best paid mechanics and frequently by the day-rate method, which has been found from experience to be considerably less economical than piece work. A greater amount of labor is also entailed, the tools

employed requiring to be dismantled, either wholly or in part, and provided with fixtures suitable for the special work to be done.

Third, the loss due to waste of material is greater in connection with the manufacture of a special machine. The raw material entering into the construction of a standard machine may be ordered ahead in large quantities and taken from the stock room in the shapes and sizes in which it is used. The raw material entering into the construction of a special machine must either be specially ordered or made up from stock on hand. When it is specially ordered a surplus may be secured, as an insurance against spoiled work, and in most cases no use can be made of this surplus and it becomes necessary sooner or later to dispose of it as scrap. Making up the parts required from available stock is an expensive process. For example, a generator shaft of odd shape and dimensions may be needed. To secure this shaft it may be necessary to take from stock a larger shaft and machine it to the shape and dimensions required, thus wasting a certain amount of material.

Fourth, a special machine requires a greater amount of general or operating expense in connection with its manufacture than a standard machine. Vastly more superintendence and clerical labor are needed in the shop, and there is an inevitable consumption of a certain amount of the time of every one concerned, from the executive officer or manager, who must express an opinion or pass judgment on the many doubtful points that are sure to arise, to the messenger who carries the written instructions or information from place to place. The expenses for testing are also likely to be greater, tests of longer duration and greater variety often being essential in order to satisfy the designer that the exceptional guarantees specified have been fulfilled and that the machine will operate satisfactorily. In addition, more expense is incurred in preparing a special machine for shipment. Extra quantities of packing material and lumber are frequently necessary, and extra supervision and labor are required in packing and boxing and, in the case of large apparatus, in loading the apparatus on cars and providing it with suitable supports.

It may be assumed that, inasmuch as the charges for both labor and material are greater in the case of a special machine, and the percentage for general expense is added either to the charge for labor or to the sum of the charges for labor and material, as already explained, the extra general expense is taken care of automatically. It will be seen, by bearing in mind the effect which special apparatus has on the cost of standard apparatus, that this can be only partially true. As already shown, it is impossible to apportion general expense with strict accu-

racy over the many types and the many modifications of these types with which manufacturers of electrical apparatus must deal. A percentage must be employed; and it is therefore evident that without a system of accounting so elaborate that in itself it would be most uneconomical, the cost of standard apparatus must be burdened with a portion of the extra general expense incident to the manufacture of special apparatus. Hence, an increase in the proportion of special apparatus must either increase the cost of standard apparatus or prevent reductions in its cost.

It will be seen that thus far the increased expenses incurred in the ordinary channels of production only have been considered.

It is customary with some manufacturers to report with the cost of special apparatus, as development, the expense incurred for special tools, for patterns, for draughting, and for engineering. The amount thus reported for a given article, however, by no means represents the entire expense incident to the development of that article; it represents only the amount which it is practicable to apportion. Special apparatus demands the highest engineering skill and the ablest supervision in the draughting, pattern, and special-tool departments, and swells the operating expense far out of proportion to the output secured.

The differences above indicated show incidentally why the computed cost of special apparatus must be greater than that of standard apparatus. It should be borne in mind, however, that they are set forth primarily as the differences affecting the absolute cost of both standard and special apparatus: and the conclusions to be drawn from their analysis are:—first, that under any practicable system of accounting only a portion of the operating expense incident to the making of a special article is borne by that article, the remainder swelling the cost of standard apparatus; and second, that only a portion of the expense for engineering and draughting incident to the development of a given special article can be reported with the cost of that article, the remainder still further swelling the cost of standard apparatus.

It needs but a moment's consideration of the differences affecting costs to see the connection between standardization and deliveries. The uncertainties as to the design and manufacture of special apparatus, and as to the time required to secure raw material, make it extremely difficult to give satisfactory promises of delivery before orders for such apparatus are placed, and after promises which appear to be safe are given, and orders are secured, extensions may be found necessary because of the unforeseen contingencies that constantly arise in the designing, manufacturing, and testing stages, and of delays in obtain-

ing raw material. Nor is this the only aspect of the delivery question which must be kept in mind and dealt with by the manufacturer. As illustrated by the case of the four machine-shop tools already cited special apparatus encroaches both directly and indirectly upon the facilities needed to produce standard apparatus, thereby interfering with the prompt execution of orders for such apparatus.

The differences affecting costs also indicate how important a bearing standardization must have upon quality. An unusual accumulation of orders for special apparatus, by making hurried work necessary, increases the liability of errors in design. It is evident that designing is a class of work which requires to be done in a deliberative manner or, at least, without that pressure which may sometimes be exerted, with advantage, on manual or clerical work of a duplicate character. Furthermore, the pressure exerted in the shop to meet required dates of delivery is apt to occasion faulty workmanship, the workmen, however skilful and conscientious, being placed at a disadvantage by their unfamiliarity with the methods employed to secure the new combinations called for. In addition to all this, with the time of his designers and mechanics taken up with special work, the manufacturer loses the benefit of that skill and vigilance which are needed to improve the quality of his standard product in order to lower its cost and increase its efficiency.

The annoyance and loss occasioned customers by inability to obtain apparatus when it is needed, or by delays in securing satisfactory operation due either to errors in design or faulty workmanship, are bound to injure the reputation of any manufacturer; and what is of more immedidate moment, they make collections difficult. Take, for example, a contract amounting to $10,000, of which $9,000 is for standard apparatus and $1,000 for special apparatus, the latter to be used in conjunction with the former. Payment under such a contract may be with-held for an entire year because of unavoidable delay in delivery or unsatisfactory operation of the special apparatus represented by $1,000, thus causing a direct loss of $600, the interest for one year at 6 per cent. on $10,000. Considering the extra expense and waste in the designing, manufacturing, and testing stages, as well as the loss on the deferred payment of $10,000, it is easy to see how the special apparatus might actually cost from 25 per cent. to 50 per cent. more than the amount received for it.

Possibly it will be inferred by some that, in so far as the problems occasioned by specialization bear upon delivery and quality, a simple solution is to be found in surplus facilities. Such an inference, how-

ever, can only be drawn by losing sight of a very practical phase of the subject. A manufacturer, in the management of his plant, must assume some reasonable ratio of capital invested and fixed expenditures to the total business to be done; otherwise most of the difficult and complex problems which confront him daily would disappear. Standardization is primarily an economic question, and in its treatment it is necessary to be guided by simple economic laws. Where these laws can be disregarded specialization need be limited only by fancy.

The benefits accruing to the local company by the use of standard rather than special apparatus are immediate and tangible. Quicker deliveries are secured, the investment outlay is less, satisfactory operation is more likely to be insured, and the cost of maintenance is lower by reason of the readiness and cheapness with which renewal parts can be secured. In short, special apparatus, though it be designed by the ablest engineers and built by the most skilful workmen, places the local company at a disadvantage in starting its plant and taxes its resources forever afterward. So far as standardization goes, the interests of the local company and those of the manufacturer must, in the nature of the case, be identical. And it naturally follows that whatever is for the best interests of the local company and the manufacturer is, in the long run, for the best interests of the public. Prices, on the average, are regulated by cost; this result is brought about either by competition or by other forces which it would be beyond the scope of this article to consider. And if, therefore, as the facts presented indicate, the standardization of electrical apparatus tends to lower costs, it is bound to be beneficial to everyone who uses electric light or rides on a car propelled by electric power.

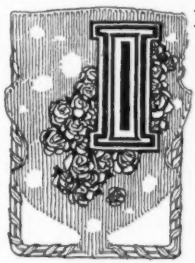
Considered with respect not only to electrical apparatus but to machinery in general, there is nothing in standardization that need alarm those who, broadly speaking, believe in the full and free exercise of individual taste. In the design of machinery intended to do work rather than to please the eye, while neatness and compactness may be essential, wholesale differentiation is surely not called for. The ordinary man, in selecting the cloth for his coat or the style of architecture for his dwelling, wishing to have ample scope afforded for his fancy, demands variety; but in buying a lathe or an electric motor for his machine shop, æsthetic considerations are of secondary importance, his chief aim being to obtain, with the least outlay, that which will best do the work required of it.

THE PROPER DISTRIBUTION OF ESTABLISHMENT CHARGES.

By A. Hamilton Church.

IV.—THE CLASSIFICATION AND DISSECTION OF SHOP CHARGES.

Mr. Church's first article, which appeared in our July issue, dealt with the vital necessity of accurate cost keeping. His second paper analysed the chief accepted methods of apportioning general expense to individual jobs and pointed out their deficiencies, and in the third article he developed a comprehensive and accurate system. His next paper will take up the application of his system to mass production.—THE EDITORS.



IN the preceding articles the practical effects of the new method have been developed, special stress being laid on the desirability of discriminating in regard to the incidence of charges, rather than seeking, as has hitherto been the practice, to throw all classes of charge into one common collection of shop expenditure, and then to average down the whole per unit of time or wages.

It might be supposed that the steps necessary to do this were very difficult and cumbrous. This is not the case, unless indeed at the outset. Once roughed out and the various factors determined, the subsequent steps present no special difficulty. It will be useful to bear always in mind the illustration already given of the "little shops," forming part of a large mill and rented out to weekly or monthly tenants. If we follow the lines that would of necessity be followed by a landlord of such a building in order to the fair proportionment of rents, we shall not be far out of our course.

The first item to be dealt with would probably be the building. For the sake of simplicity, we may assume that this is of one storey only. There is, of course, no difference in principle whether the building be one of several storeys high. As a matter of fact this method was first worked out for and applied to a factory which consisted of two parts, one being an old building of five storeys, and the other a modern shop of three. The process is the same in any case. All the factors of capital and revenue incident on such building are carefully mapped out. The capital invested in land has first place. To

this is added the cost of the building. Particular care is taken to consider whether any inequalities in cost in the various parts of the latter are significant or accidental—that is, whether they have any special reference to the *uses* of that part. Having exhausted the capital items, they are reduced to floor areas. That is to say, every square foot of floor space not subject to special conditions is considered as representing so much capital outlay. Having determined this, the charges incident on the floor space due to this capital outlay are ascertained, then interest, ground rent if any, taxes, insurance, depreciation of buildings—all are reduced to figures, and therefore to so many pounds or dollars per square foot of floor area. The first cost and working expenses of heating and ventilating appliances are treated on a similar footing.

When this is finished, with any factors peculiar to the local circumstances taken to account, we have obtained a pretty close idea of what rent charge is due to a production centre occupying say 13 square feet of working space. Whether we are determining the figures for the purposes of subletting our building or for determining the correct incidence of such items of expense in a large shop, makes no difference whatever to the process or its result. So many square feet of floor, so many dollars per annum out of pocket. If machine A occupies twice the space of machine B, it is costing us just twice as much to house it. There seems to be no escape from or alternative to this position.

Where shops are electrically lighted by overhead lights, the cost of this also is reduced to a floor-area basis. The items include:—Charges due to the capital sunk in leads, switches, lamps, and in some cases where the light is generated on the premises, a due proportion of the cost of the generating plant; interest, insurance, and depreciation is taken out on these sums, and to the result is added the actual cost of power or current, carbons, cleaning, and so forth. Here again we get a rent representing the cost of lighting either one of our little shops or a given area of a large shop.

Two items are thus complete—first, a rent for the empty shop or area, second, the rent of the same lighted up. The shop is, in fact, ready for occupation and use.

Probably the cost of power will be the next item dealt with. This is a more complex subject, still not insuperably so. The capital outlay on engines, boilers, motors and generators, main shafting, and pulleys being ascertained, and the resulting revenue charge therefrom, to this is added the running expenses—fuel, stoking, repairs, and so forth, reduced to a value per horse-power hour. There is not much

difficulty in the broad working out of this figure, but the position of shops and various local details make the problem a little troublesome. In some cases the cost of power might not be the same in all parts of a large mill or scattered group of shops. This is a matter of which the practical aspect will vary, and no definite rulings are possible. It is evident that in many cases the charge for power should not be averaged. The cost of transmitting power to a distant shop might sometimes give rise later to the adoption of more efficient means of transmission, and this should of course show in the charges of that particular shop alone, and not reduce the average cost of power in other places which have nothing to do with the improvement. In most cases, however, the average charge per horse-power hour would meet the case fully.

The shops are now ready for the introduction of machines.

The charge due to interest, depreciation, and insurance on the value of machines is of course the item which the new method has in common with the ordinary machine-rate plan. These charges are calculated per annum and then reduced to a rate per hour, based on the probable number of hours the machine will be in work under normal conditions. Thus, if we take the annual work of any machine to be 2,500 hours, and the annual charge for interest, depreciation, and insurance to be $150, this gives an hourly rate for these items of 6 cents. The ordinary machine rate being extensively understood at the present day, this particular item need not detain us farther. It should be noted, however, that the items of annual or hourly charge for interest, depreciation, and insurance do not form the whole machine rate as on the old method, but are but one of many factors, of which several have already been described. The new method includes all that was signified by the old machine rate, and several other items as well.

It should be mentioned that along with each machine are included countershafts, fencing, belting, or motors, which are specially used to operate that machine alone. Some care is necessary to discriminate between what may belong to individual machines and what pertains more properly to the main system of power transmission.

In addition to the empty shop lighted and heated, with its necessary main system of power, we have now considered the machines installed and ready for working. It will be evident that up to this point the charge incident on the work done on any machine will be made up of:—(1), a rent charge for the space occupied; (2), a charge for the capital sunk in the machine itself; and (3), a charge for power calculated according to the average amount used by the machine. None of these

items can be imagined as being other than properly connected with the particular work done on any given machine, or as having on the other hand any connection with work done on other machines, whether they happen to be fixed under the same roof or not. We have, in fact, not so much differentiated as kept separate these factors of production cost, which on the ordinary methods of averaging shop charges are jumbled up in one common account.

There remain, however, other items perhaps not so definite, but yet capable of being worked out into reasonable approximations to the truth. Of these are the costs of overlooking and supervision, which are frequently special to a limited group of machines, as, for example, in the case of a sub-foreman in charge of a half-a-dozen screw-making machines or turret lathes. The approximate cost of such supervision for a year can be taken, divided by the number of machines, and reduced to an hourly rate per machine. The importance of confining a special charge of this kind to just that class of work that incurs it, instead of letting it become part of a general shop charge and thus become spread over all the work of the shop, will be clear. The same result might, of course, be attained by a very elaborate system of allocating such overlookers' time on a cost sheet, but this would be much more troublesome and not appreciably more accurate than the plan proposed. It would be, in fact, *less* accurate, as will be seen when the question of partially-idle groups of machines is considered in the article on mass production.

The cost of tools may in some special cases be similarly treated, as for example the wheels on emery machines, cutters on milling machines, etc. This requires very cautious treatment. The same remark applies to charges for oil, or other material such as rouge, used in particular processes. Such materials frequently form a very serious item in the true cost of a process, and the justice of including them in the working expenses of a production centre will be felt if the case of the separate little shops is considered. The expenses of such a little shop doing polishing work by means of a buff wheel will be readily allowed to be made up of the standing charges already detailed plus the value of actual emery flour, rouge, etc., consumed on the work. And that substantial accuracy is attained by reducing such item of expense to a charge per working hour will be admitted if we assume, as we are entitled to, that the same machine employed on the same class of work uses approximately in proportion to the amount of work got through. If from the evident circumstances of the case this were not so, then other arrangements would be necessary. The rate

might, for example, be higher when engaged on one class of work than for another. It has already been stated that an item of this class requires very careful consideration.

The principal items of shop expenditure are now accounted for. Those remaining comprise the wages of general foremen, and the cost of repairs done to the buildings, to power, transmitting, lighting, and heating plant, and to the machines themselves. This latter question, being mixed up with that of depreciation, needs some discussion.

The usual view taken of a depreciation rate is that it is a fixed percentage, say five per cent., on a gradually lessening value. The effect of this is to transfer the cost of a machine from the plant account at the outset of its career to the depreciation fund at the end of its life. The value of the machine, if plotted graphically, would show a series of intermediate values year by year, each rather less than that of the previous year. From a financial point of view this is correct. As the machine wears out its value as an asset decreases, and the provision for its renewal in the depreciation account increases. It is usually understood that the cost of minor repairs during working life is being met out of revenue. Therefore such repairs are properly a shop charge. Repairs or alterations, on the other hand, which practically give the machine a new lease of life, should be charged to plant account, wholly or partially according to circumstances.

The question which interests us here is:—How should the cost of repairs which are met out of revenue be dealt with under the new method? It is evident that they can be either kept isolated from all others and in connection with the particular machine or item of plant that has incurred them, or else be treated as a really general shop charge, such as foreman's wages.

The principle of the new method being to keep all expenditure individualised, wherever it can be done, it follows that arrangements must be made to give the cost of repairs expression in the various rate factors which go to make up the total new machine rate.

As the charging of repairs is always an *ex post facto* transaction—that is, the work done by reason of which the repairs have become necesary cannot possibly be charged with them—it will serve the purpose if such repairs be averaged over half-yearly periods, though still kept confined to the actual machines involved. Thus, if the power plant has been overhauled, the rent charge for power may be correspondingly increased at the next half-yearly balance, until such extra and abnormal expenditure has been wiped out. Generally, therefore, it will be seen that an estimated figure for cost of repairs

is included in the various factors of the new machine rate, and this estimated charge is subject to periodical revision, if on examination it is found to be too high or too low.

It may be objected here that we are here breaking away from actual figures, and entering the nebulous region of estimated charges, which it is the purpose of the modern methods of accounting to avoid. The answer is that the breaking away is only temporary, and that the cost of repairs is more properly averaged over a more or less extended period than borne by any particular month in which they may have happened to be executed. And when it is remembered that the alternative to this method of averaging is the throwing of the cost of such repairs into the general fund of shop repairs, and spreading it away over the work done in a given month, with which it has manifestly no proper connection, the propriety of the plan advocated will not be in doubt. By this means, the cost of repairs to a turret lathe, for example, is kept incident on the work of that turret lathe and no other; and as no particular item of the current work can by any possibility be imagined to bear properly the burden of such repairs, no substantial injustice is done by a temporary want of co-incidence between the actual rate of expenditure in repairs and the estimated rate. On the other hand, the individualising principle is kept intact, and this is the more important object to keep in view.

Necessarily, the estimate for repairs included in the new machine rates must be no hastily determined or fancy figure. Throughout this method the preliminary determinations must be most carefully made. If this is done, then their subsequent variation will be an easy and almost automatic matter. If we recur to the case of the little shops, the justice of the foregoing contentions will be more clearly seen. It is evident that the cost of repairs to any one machine are part of the expenses of the little shop it is in. But, again, it would not be correct to charge with the extra cost the work which happened to be done in a week or month in which such repairs were carried out. More substantial justice would be done by estimating in advance the probable expenditure, and including that in the hourly rate charged on the work. Then, if at the end of a six months' period it was found that this amount had been underestimated, the small amount representing the *difference* between what was actually spent and what was charged to jobs as an estimated figure would be adjusted by raising the rate slightly.

The question of repairs done to the power plant or to the buildings of the little shops seems to present more difficulties. It seems clear that

the landlord could not charge more for power or for rent because he had just spent a certain sum in repairs, merely to keep up the efficiency. On reflection this will be seen to strengthen the case for the averaging method. For the reason why no more rent could be charged is that, in fixing the rent in the first instance, the probability of a certain expenditure for repairs was foreseen and allowed for. It was, in fact, averaged in advance. And any discrepancy, any failure to estimate correctly the probable cost of repairs would, in the landlord's case, come out of his profit. It would be a dead loss to him. In the case of a large shop, however, there being no item corresponding to the landlord's profit to fall back on, the recovery of this unforeseen expenditure from the shop is the only course open. It must be got rid of by becoming an expense chargeable to work, and this is done simply enough by raising the rent charge per floor area, in the case of repairs to buildings, or per horse-power hour, in the case of the power plant.

The treatment of all these items is thus identical, whether we are considering the little shops or a number of productive centres in a large shop. It will be necessary now to consider the case of those charges which have no parallel in the little shops, such as foremen's wages, which press equally on a number of productive centres.

As there is no natural line of cleavage herein, no reasonable presumption in favour of such items being connected with one productive centre more than with another, we are compelled to treat them as really belonging to the category of general or non-individual shop charges, and thus to distribute over the work as a whole, on the hourly-burden plan for preference. The principle of this method has already been explained, and there is nothing special in the treatment of these general items which differentiates them from the ordinary distribution of shop charges by hourly-burden. When all the machines or production centres are running full time, there is nothing in the shop-charges account to distribute but non-individual items. All the rest will have been already allocated to particular jobs by means of the new machine rates.

It is when this is the case that the differences between the present method and any previous one are seen at the full. Out of all the many items of expenditure which go to make up the ordinary shop-charges account, and which are usually lumped together and spread like a thin paste equally over all jobs in strict proportion to time occupied only, we find but one or two items, themselves of relatively small amount, remaining to be treated in this way. All the main items

of expenditure have, by following the natural lines of action, been kept immediately connected with the machines and therefore with the jobs done on such machines, on which they are properly incident. The large and expensive machine bears its own burden; so does the small and cheap machine. Their vicinity in the same shop does not have the effect of altering each other's shop-charge incidence. The introduction of a special overlooker on a small group of machines does not send up the hourly burden, and thus affect the work of the whole shop; it is confined in its effect to the machines and their work on which the increased expenditure was actually incurred. Throughout the items of expenditure have been not so much individualised as *kept* individualised, and thus preserved from mutual interference—just as much as if they were actually as well as hypothetically incurred in separate little shops. It would be hard to argue that this is not a decided gain or that it is not worth the trouble involved, whatever that may be proved to be. If it is worth while attempting to connect establishment expenditure with work at all, it is certainly worth doing so in a way which closely represents actual facts.

Having thus considered in some detail the method of organising the shop charges on the new method, with the result that it is demonstrated that when all the productive centres are making full time the great bulk of shop expenditure finds its way to the actual jobs on which it has been incurred, it remains to show what happens when there is a large proportion of idle time in the shops. In such case, while the work actually going through will as before be charged with its due expense as hitherto, there will obviously remain at the end of the month a certain amount of undistributed charges, exactly proportional to the idle time of the various productive centres.

This balance, together with the really general (or non-individual) shop charges remains to be got rid of. This is effected by means of an hourly-burden rate. There are thus, under the new system, two rates which enter into the cost of each job; 1, the new machine rate, which remains the same whether the shop be busy or slack; and 2, the hourly-burden rate, which it is proposed to call the "supplementary rate," since by its aid we spread away all the residual charges, which would otherwise escape allotment. This rate necessarily rises when there is a large proportion of idle machines, and falls when idleness is at a minimum. The supplementary rate thus becomes a significant index to the commercial efficiency of the shop. It should be the aim of the authorities to keep this rate as low as

possible. Its rise when work is plentiful will be a sign of the most automatic nature that something is going wrong.

It may occur to the reader that the more appropriate way of dealing with idle-machine time would be to distribute the unallotted machine-rate amounts, not as part of the general shop expense, but as a kind of supplementary machine rate, thus confining the effect of idleness to the particular machine in fault. This would certainly be the ideal method, but it is not practicable under ordinary circumstances; the reason being that if a machine were to work only one hour in a given month, all the burden of the other two-hundred-and-odd hours would be discharged on the unfortunate job done in that one hour. And worse still, if no work at all were done in the month the unallotted rate would either be lost altogether, or else thrown into the supplementary shop rate after all. We are obliged therefore, from motives of expediency, to look upon idle time as a kind of visitation of Providence which the whole shop ought to bear.

It is true, no doubt, that we do here depart from the parallel case of the little shops, which we have endeavoured to be guided by. In their case, the accumulated burden due to slack times would have to be borne by whatever work was done in the month, but then in the extreme case of an almost complete idleness for a long period, such as a month, it would probably be a case of bankruptcy for the little shop. This alternative, as in the former case of the landlord's profit, has no parallel in the case of a large shop embracing many productive centres. The shop as a whole properly comes to the rescue of the idle machine and shifts the unallotted burden on to its broader shoulders.

The full effect of the new method, as contrasted with the older averaging methods, such as either the percentage-on-wages or the hourly-burden plan, may be glanced at. Briefly, it may be said that in all three the whole of the charges incurred in the month is spread away over the work done in that month. But whilst in the two former the distribution is on an arbitrary basis, on the new method the greater bulk of the charges allocated to a job are really what has been incurred under the actual conditions. If these conditions are varied, then although the number of hours or the direct wages may still remain the same, the amount debited to the job for shop charges will not remain the same. They will vary exactly in proportion as the resources called on to effect the variation are more or less expensive than before. On the two older methods they would not vary, provided the time or wages value remained unchanged.

Again, in the new machine rate we do get a factor of cost which is just as significant as the wages itself. It is a factor which varies as method varies. Cheaper methods of doing work will be promptly reflected in this factor. And the significance of the supplementary rate has already been alluded to.

In comparing two costs on the new method, we have three factors to read, each of which conveys spscial information:—1, direct wages—nothing need be said about this; 2, the machine rate; this will show whether a change of method or process has resulted in an economy if read in connection with wages. If cost has varied, it is easy to see wherein it has varied—the play of the three factors of time, wages, and machine rents being distinguishable—and deductions can be drawn whether there has been a net gain or loss by the change of method. For it will be seen that a decrease in wages may be counterbalanced by a rise in machine rent, or the shorter time taken by a high-priced man may be found to have a corresponding gain in a lower charge for machine rent. In fact as before said, the play of the factors amongst themselves and their mutual relationships can be studied minutely. This is impossible on any of the averaging methods.

Finally, there is the supplementary rate, the third factor of cost. This will be of chief significance as showing what proportion of the total cost was due to the accidental features of the commercial situation at any period. This factor has never been separated before from the general body of the costs. On an averaging system, if we find a reduced cost to-day as against the cost of the same article a year ago, we cannot, if the method has in the meantime been varied, say what is the reason of the reduction. The manufacturing efficiency due to method was intermixed with the commercial efficiency due to state of trade. In the new method, the state of trade or the general efficiency of management affect the supplementary rate alone, and a similar cost at two different periods might, if analysed, show that what had been gained in method had been neutralised by a fall in the volume of trade, or by a muddled condition of shop organisation.

In the next article some of the problems raised by the application of the method to mass production will be discussed, especially with regard to the influence of nearly automatic machines. One or two examples of job costs under varying conditions, and the lesson that may be read from an examination of them, will be presented.

THE DEVELOPMENT OF THE BY-PRODUCT COKING INDUSTRY.

By William Gilbert Irwin.

Possibly the most striking phase of modern manufacturing economy is the progressive utilisation of former waste products. As the competitive struggle for existence becomes keener, more study is put upon extracting values from materials formerly thrown away. Europe has centred attention more closely upon this point. In the United States, materials being lavishly abundant and labour expensive, the study of lessening the cost of production naturally took at first a different trend. There is a tendency now to approximate practice in this line, as in all others, and Mr. Irwin considers a development in which America has most to learn from Britain and the Continent.—THE EDITORS.

THE development of manufacturing industries to their present greatness has been due in a large degree to the advances made in fuel supplies. Just as anthracite coal succeeded charcoal in the United States for furnace and foundry purposes so, too, has coke supplanted the latter fuel product. For many years there were no marked advances in the improvement of fuel coke, but to-day the coke industry is undergoing a decided revolution in the methods of its operation. Changes in coking operations, long foreshadowed by economic conditions of fuel production and involving nothing less than the complete eradication of the old bee-hive oven and the substitution of the various new by-product systems of coke making, are now under way in the coking fields of the United States. In addition to bringing about decided improvements in the manufacture of fuel coke, these new economic systems, at the same time, will make possible the complete utilization of the valuable by-products which are an entire waste by the bee-hive-oven system of coke manufacture.

Were these propositions yet in their experimental stages, such radical innovations might seem chimerical even in these days of science and economy as applied to industrial operations. However, by-product coking has already had considerable exploitation, especially in European countries. In the coking fields of continental Europe the various types of the by-product system have pretty

thoroughly supplanted the bee-hive oven. The same is now true of the coking fields of England, the coke makers of that country finally following the lead of Germany, France, and Belgium. While by-product coking has made some progress in the United States during the past eight or nine years, American coke makers have been slow to adopt these economic systems. But it must be remembered that a radical change from the bee-hive oven system, now in general use in the United States, involves a gigantic financial problem. Estimating the cost of a complete bee-hive oven at $400, we would have invested in the 50,000 ovens of this type now in operation in the country not less than $20,000,000. To supplant these ovens with a sufficient number of by-product ovens to insure a maintenance of the present annual coke output would cost something like $40,000,000. With such enormous sums at stake, it would scarcely be a good stroke of business to abandon at once the old coking methods for the new types, even though the utilization of the by-products would insure a handsome annual profit over the old bee-hive system.

While the advantages of the new system are apparent and manifold, all the foregoing would indicate that their introduction must be the result of a slow change from the old to the new ideas. In these days of prosperity the loss of time resulting from a radical change in methods of coke making would mean a loss of millions of dollars to the operators. Today the result of one day's operation in this form of fuel making easily yields the same returns financially as did three days' operation a few years ago, when the coke industry was at ebb tide and coke was selling for one dollar per ton. Today the vital question with iron and steel manufacturers is to obtain their coke supply; the method of its manufacture and its quality, in most cases, are secondary considerations. Illustrative of this fact I may here state that the coke makers of the Connellsville region have been resorting to numerous experiments looking to increases in their output, but it is plainly evident that the only logical solution of the question of time-economy in coke making lies in the adoption of the new by-product coking systems. All attempts to reduce the time of coking by improvements in the bee-hive oven have resulted unsatisfactorily. When coke was first manufactured in the Connellsville region no ovens were used, the coal being banked in huge piles in open ricks on the ground, with air channels running through to give air draughts, much after the manner in which farmers burn lime. In this primitive method, which is today being resorted to in order to increase the coke output, it requires a much longer time to complete the coking process than when ovens are used;

but so far as concerns the chemical enrichment of the product, this primitive system is almost on a par with the bee-hive oven. These open coke ricks in no way interfere with the operation of the oven plant, and the coke thus produced is a clear gain in production. With a natural coking coal, such as that of the Connellsville region, this open-air coke making has no apparent deleterious effect upon the product. In semi-coking and other coals it would be altogether impracticable, as would the successful operation of bee-hive ovens.

But even in the face of these prosperous days for the coke industry, the by-product question is by no means a dead one with American coke makers. Like the fuel producers elsewhere, they are rapidly coming to understand better just what the new coking systems mean in dollars and cents, and to see how they will be enabled by these new systems to turn to profit those products of coke making which are entirely lost by the bee-hive-oven system.

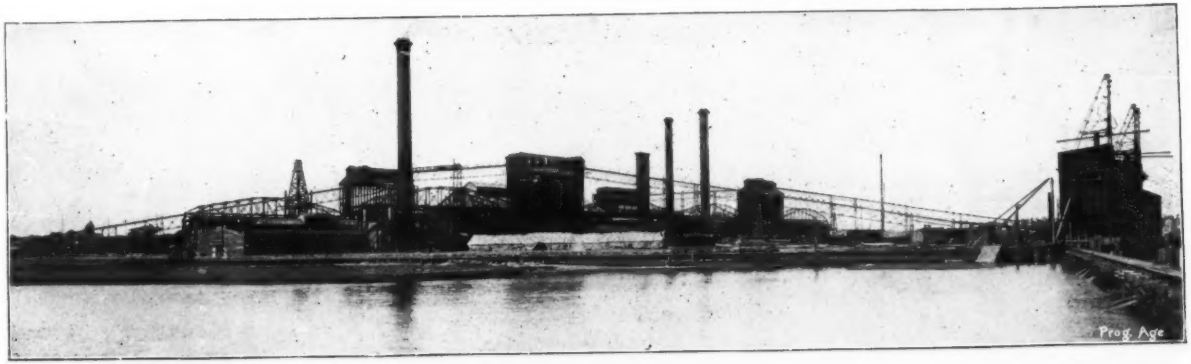
The story of the inception and growth of the ideas of by-product coking is by no means written history, for although we have frequent mention of the progress and development of these ideas in former years, yet there is little known of the vicissitudes which must have been encountered by the early advocates of the new type of coking ovens. We infer from the slow introduction of these plants and from the fact that all pioneer exploiters of new ideas in science and industry have been thus obstructed, that much difficulty was experienced by the early advocates of the by-product coking methods.

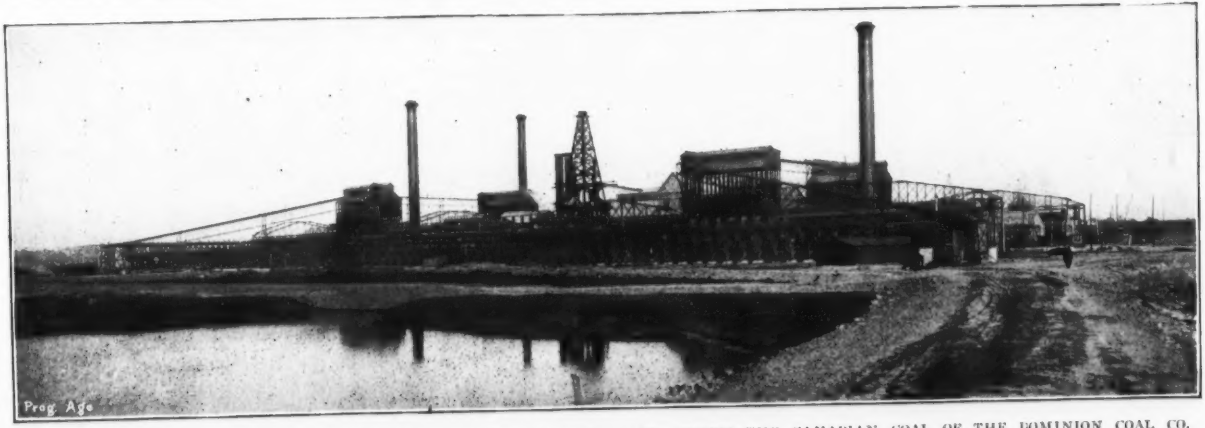
These new coking plans were originated in Germany, France, and Belgium, and these countries still hold the foremost rank in the use of the systems. While America leads the world in mechanical and inventive genius, the new coking system forms one of the few exceptions. The right of the countries of continental Europe to pre-eminence in the field of chemical research has not, however, until recently, been disputed by the United States, and as the by-product coking industry readily resolves itself into a complex chemical one, its evolution has lain more directly within the field of the careful and learned men of Europe than within the field of the busy American. Another incentive to the development and introduction of these new ideas in the coking fields of continental Europe lies in the fact that their coal supplies are comparatively limited; hence the necessity of rigid economy.

The first mention of the by-product oven dates back to 1768, in which year tar was produced by a chemical process in a by-product oven at Fischback, in the Saarbrucken coal fields in the Rhineland provinces of Germany. Systematic experiments along these lines were

made in France and Belgium many years ago, and in 1863 a by-product-oven plant was in efficient operation at St. Etienne, France. From that time until 1882, when Mr. L. Semet, an eminent engineer and a director of the firm of Solvay & Company, of Brussels, Belgium, perfected the Semet-Solvay retort coke-oven system, this departure in fuel making underwent a gradual development. The first plant of this pattern was installed at Mons, Belgium, in 1882, and since that time the system has met with great success in many coking fields. A little later the Otto-Hoffman system was perfected in Germany, and under the exploitation of leading German fire-brick manufacturers this system has had a wide development at home and has been successfully introduced into the coking fields of other countries. In the meanwhile the Simon-Carve by-product system was being perfected in France, and during the past ten or twelve years a number of other systems modeled somewhat after these pioneer retort systems have been evolved.

These new systems of coke making were slow to obtain favor with the English coke makers. There the same conditions which now confront these new systems in the United States were met. In 1882 Sir Lowthian Bell, an eminent authority on such matters, conducted exhaustive tests based on the operation of the Simon-Carve by-product system, and in his published reports he advised against the introduction of the new systems, stating that the coke thus produced was at least 10 per cent. inferior to the bee-hive-oven product for furnace, foundry, and other industrial purposes, and his reports were otherwise adverse to the introduction of the new systems. However, the best authorities are liable to error, and later experiments proved that Sir Lowthian was wrong in his deductions. It remained for Sir Burnett Samuelson to dispute the conclusions of the above mentioned authority, and by conclusive experiments and actual tests to show that the product of the new systems was superior to the bee-hive-oven coke, the coal being coked in ovens of the opposing systems having the same uniform composition. But even these conclusions, coupled with the acknowledgement of error on the part of Sir Lowthian, did not for a time completely remove the skepticism on the part of the English coke makers. It required almost a dozen years for the by-product methods as represented by the Semet-Solvay and the Otto-Hoffman systems, to obtain a firm foothold in England. These and other systems have been in very successful operation in that country for the past eight or ten years, and the by-product-oven output now forms an important part of the coke production there, while the utilization of the by-products and the conversion of these to the uses of modern industry now form a





EVERETT WORKS OF THE NEW ENGLAND GAS & COKE CO., BOSTON, MASS., WHERE THE CANADIAN COAL OF THE DOMINION COAL CO. IS COKED IN OTTO-HOFFMAN BY-PRODUCT OVENS.

valuable subsidiary industry in that country. By-product coking plants are now in operation in all the coking fields of continental Europe, in Australia, and in Japan, and today the greatest activities in these new ideas are being experienced in the United States and in Canada.

The Semet-Solvay and the Otto-Hoffman systems represent opposing by-product types, in so far as operation and by-product recovery is concerned; and both of these systems are represented by a number of plants in operation in the United States today. The chief points of difference in these two types lie in the fact that the Otto-Hoffman uses vertical flues and employs the regenerative system of firing, while the Semet-Solvay process uses horizontal flues and employs the continuous recuperative firing system. The points of merit possessed by these two types will be discussed farther on in this article. The Coppee by-product system is a later system evolved by E. Coppee of Brussels. It employs vertical flues without regenerative firing. The Simon-Carve system employs horizontal flues and thick walls, and differs from the Semet-Solvay system in that the latter type employs thin, or hollow, walls. C. Bernard, a Frenchman, has perfected a system similar to the Coppee oven and this system is now in use in France. The Bauer by-product oven is now used at the Hanover collieries of the Krupps. This type of the by-product oven is built in small units and with either vertical or horizontal flues. A plant of this type with vertical flues is now in operation at Creusot, France. The Newton-Chamber by-product oven is the production of English skill, and is modeled somewhat after the Otto-Hoffman system, using vertical flues and involving continuous firing. Two plants of this type have been installed in the United States.

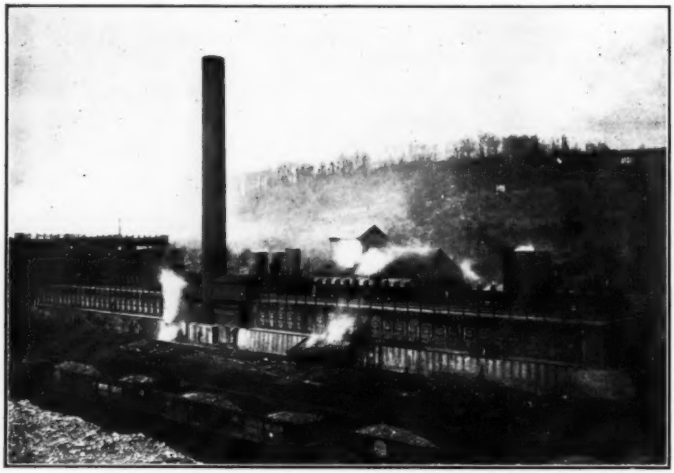
All of the above are European systems. In America a number of by-product coking systems have lately been evolved. A plant of the Keneval system, consisting of three ovens, has been installed at Knoxville, Tennessee. This battery is of three ovens, 25 feet in length, 24 feet 6 inches in width, and 21 feet high, with ascension pipes and hydraulic pipes on the top. The charge of each of the ovens is 10 tons of slack, the return in coke being from 75 per cent. from washed slack down to 68 per cent. from unwashed coal. Coal from mines in all parts of the country has been coked at this experimental plant. This by-product system differs materially from all of the European systems.

The Hemingway retort-oven process is another of the new systems now being perfected, and John Fulton, the well known coal and coke expert long connected with the Cambria Steel Company at Johnstown,

Pa., has perfected a by-product coke oven. The Slocum retort oven is the work of Dr. F. S. Slocum, of the Pittsburg Gas Company, and several of these ovens have been installed at Bolivar, Pa. The Jones & Laughlins Company, of Pittsburg, has lately installed a complete retort-oven plant on South Side, Pittsburg, at which plant the slack coal from their mines is coked at the point of consumption; but as yet this company has made no uniform attempt to utilize the by-products.

PLANT OF 30 NEWTON-CHAMBER BY-PRODUCT COKE OVENS, LATROBE COKE AND COAL CO., LATROBE, PA.

All retort ovens are closed and air-tight, at least during the coking process. In shape and operation they differ widely from the old bee-hive oven. This oven, of which over 50,000 are in operation in the United States at this day, is a square oven, built usually in blocks, and the standard oven of this type has an outside diameter of about 12 feet and a height of 8 feet. Its interior much resembles an old-fashioned bee-hive, from which it derives its name. There is a circular opening in the top, through which the oven is charged and through which the gases are permitted to escape into the air during the coking process. The door in the lower front side is closed during the time of coking, and it is through this opening that the coke is "drawn." In this system no attention whatever is given to the recovery of by-products. In the various recovery systems the coking chamber is very narrow, varying in width from 15 to 30 or 40 inches, save in the Newton-Chamber and several of the other systems which have a wider coking chamber.



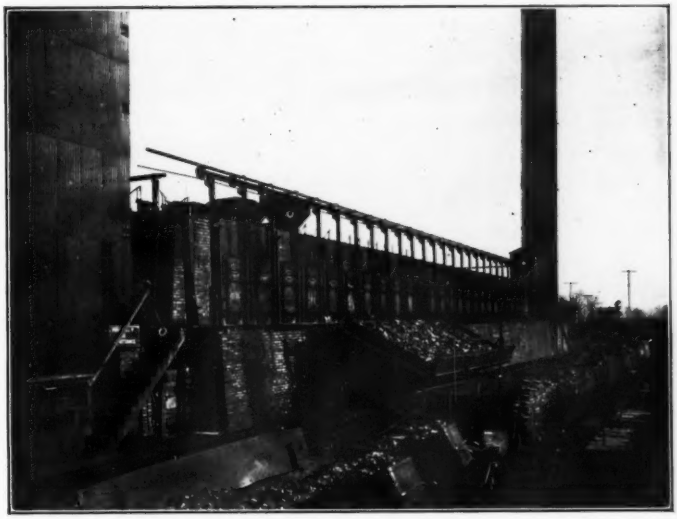
SEMET-SOLVAY COKING OVENS AT DUNBAR, PA.

The height of most of the by-product ovens varies from 7 to 8 feet. The exclusion of air from the coking chamber does away with combustion there, and the heat necessary for coking comes from the combustion of air and gas in the flues, and in the sides and bottoms of the ovens.

No provision for the chemical enrichment of the product is made in the bee-hive oven, nor is there any provision for definite results. When the charge is leveled in these ovens there remains a foot or more empty space in the top part of the oven. In this system the mass of coal, as it fuses into coke, swells and rises, and if on quenching it falls back to nearly its original bulk, a hard coke is produced; otherwise a soft coke results. The bee-hive oven is adapted for coking a natural coking coal only, while the retort oven, it has been demonstrated, will to a large extent adapt itself to semi-coking coals, and in many cases a good quality of coke has been produced by these new systems where the bee-hive oven has proven a complete failure. Nor does the retort oven admit of variation in the product. When the mass of coal is being fused into coke in the narrow retort oven it cannot expand, and is compressed vertically as well as laterally; the result is a uniform product, its hardness varying according to the charge of coal in the oven. For foundry and furnace purposes bee-hive-oven coke is superior to anthracite coal, but in some respects inferior to by-product-oven coke, especially when the two cokes are produced under similar

conditions. Anthracite coal was at one time a bituminous coal, and in its present state it is really a coke produced by nature, the excess volatile matter and other original chemical constituents having been expelled by the forces of nature during the earth's chaotic period. This coal is much freer from volatile matter than ordinary coke and it contains more carbon, but these advantages in its favor are overbalanced by its density, which is caused by the great pressure to which it was subjected while in its semi-plastic condition. In the bee-hive-oven coke the porosity is great, but toughness and hardness, two essentials of a perfect furnace and foundry fuel, are not always rightly combined. Through the equal distribution of the cell space and the greater amount of carbon present in the by-product-oven coke all the essentials of a perfect fuel for industrial operations are eminently combined. Later on some statements and statistics relative to the comparative value of the bee-hive and by-product-oven coke will be given.

The by-product-coking industry, so far as concerns the American coking fields, dates from about January 1st, 1892, when The Solvay Process Company, manufacturers of soda, put into operation an experimental plant of twelve ovens with by-product-recovery apparatus, at Syracuse, N. Y., for the purpose of obtaining a coke supply for their works, and also to produce ammonia for their soda manufacture.



SEMET-SOLVAY OVENS AT SHARON, PA.

For several years these ovens were successfully operated, during which time nearly all kinds of American and Canadian coking and semi-coking coals were thoroughly tested, and the coke thus manufactured was subjected to the most rigorous furnace and foundry uses with gratifying results. The increased production of these by-product ovens over the bee-hive oven ranged all the way from 15 per cent. to 40 per cent.

Shortly after the successful installation of this plant, the Semet-Solvay Company was organized to develop the use of these ovens in the United States. The first American coke-making concern to adopt this by-product system was the Dunbar Furnace Co., which installed a plant of fifty of these ovens at Dunbar, Pa., in the heart of the Connellsville coke region, in 1895; and the operation of this pioneer by-product plant has been so successful that the erection of an additional lot of ovens is contemplated, which will bring the plant up to over two and one-half times its present size. A few months later a plant of twenty-five of these ovens was put into run by the Sharon Steel Company, at Sharon, Pa., and in 1897 a plant of sixty ovens was built by the Riverside Iron Works at Wheeling, W. Va., and since that time the plant has been increased to one hundred and twenty ovens, the increase being of the new type of oven having 6-tons capacity per twenty-four hours.

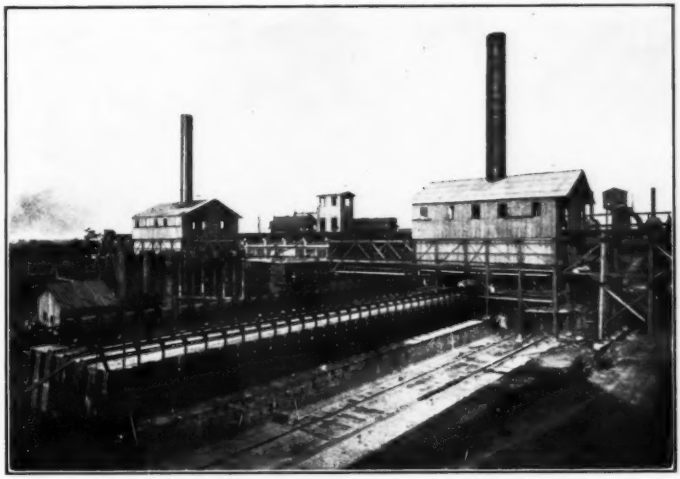
At Ensley, Ala., in 1897, a plant of one hundred and twenty ovens was built to supply the blast furnaces of the Tennessee Coal, Iron, & Railroad Co. with coke, and during the past year this plant has been more than doubled in size. The gas is being used very successfully in the steel plant of the Alabama Steel & Ship-Building Co., and has very thoroughly proved its value in metallurgical work.

During 1898 a plant of ten ovens operated by the Peoples' Heat & Light Co., at Halifax, N. S., was changed to the Semet-Solvay type, the coke being sold largely for domestic consumption and the gas being used as the sole gas supply for lighting the city of Halifax. This plant was the first to use coke-oven gas successfully for illuminating purposes without enrichment.

A plant of 200-tons daily capacity is just being put into run at Detroit, Mich., in connection with the branch of The Solvay Process Company's works there, and a number of other plants varying in size from two hundred and forty to one hundred and twenty ovens each are in the preliminary stages of construction or under active negotiation.

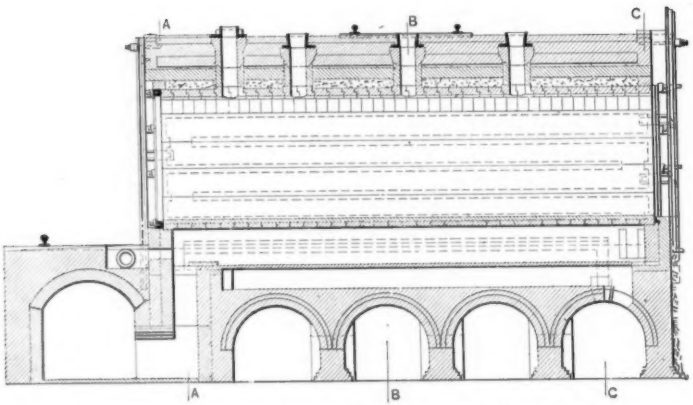
The Semet-Solvay ovens are built in batteries, preferably of thirty

ovens each, or multiples thereof. A single oven is 30 feet long, 7 feet 6 inches in height, and from 16 inches to 20 inches wide. The distinguishing characteristic of oven construction is illustrated in the accompanying longitudinal and cross sections. It will be seen that the ovens belong to the horizontal-flue type—that is, the oven chamber is heated by means of four horizontal flues on each side. These flues are heated by the combustion of gas which is admitted at the ends of all but the lowest flue, where it mixes with air heated by means of the regenerative arrangement shown at the bottom of the oven, which produces amply high temperature for the operations of the coking process. The horizontal-flue system has the important advantages of permitting the inspection of any flue at all times, and the accurate dis-



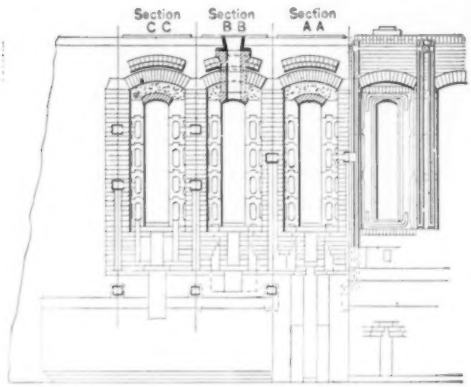
ENSLEY, ALA., BY-PRODUCT-COKING PLANT. SEMET-SOLVAY OVENS.

tribution of the heat in the flues so as to prevent the possibility of uneven heating of the coking charge. It will be noticed by examination of the cross-sectional view that the tiles composing the flues are entirely independent of the main structure of the oven. This permits the expansion and contraction of these flues, due to the change of temperature from the time when the cold wet charge of coal is dropped into the oven up to the completion of the coking process, without in any way affecting the main brickwork of the oven construction. This insures a very much longer life to the ovens than where the flue walls



LONGITUDINAL SECTION OF SEMET-SOLVAY RETORT COKE OVEN.

form an integral part of the system and the whole mass of brick work is distorted and racked by the repeated expansion and contraction of the flue walls, which is an essential part of the process of charging, heating up to the final coking temperature, and discharging of the coked charge, which takes place every day in each oven. The waste gases pass from the oven flues into a general collecting flue, thence to the boilers, where they furnish steam for the operation of the by-product apparatus, and pass to the chimney at so low a temperature as to be of no further value. The ovens are charged through three openings in the top, the charge being from 12,000 to 12,500 pounds to the oven. The charge is leveled by means of hoes operated from each end of the oven and the oven doors tightly sealed with fire-clay luting; and the gas, which begins to come off immediately, is turned into the mains for treatment in the by-product apparatus.



TRANSVERSE SECTION OF SEMET-SOLVAY OVEN, REFERRED TO LONGITUDINAL SECTION ABOVE.

The time of the coking depends upon the quality of the coal and width of the oven. With Connellsville coal, containing 32 per cent. volatile matter, coke is produced in Semet-Solvay ovens of the usual width, 16½ inches, in from 20 to 24 hours, while but 18 to 20 hours are required to coke Pocahontas coal containing 19 per cent. of volatile matter; an increase in the width of the oven increasing the coking time about proportionately. There may be a difference in the time of coking two coals containing the same percentage of volatile matter, owing to the differences in the chemical composition of the volatile matter.

At the close of the coking process, the doors are opened and the coke discharged onto a car specially arranged for receiving the coke and quenching it with the greatest thoroughness. The doors are closed as soon as the ram is withdrawn and a fresh charge introduced, the whole operation of pushing and recharging occupying but a short time.

The control of the temperature of the flues is of special importance for the production of good coke, and the method of admitting the gas into several places and at the ends of the horizontal flues, which is adhered to in the Semet-Solvay system, has been found to be of special value. The top flues of the oven are maintained at from 800 to 1,000 degrees centigrade, the middle flues from 1,150 to 1,250 degrees, and the bottom flues at about 1,100 degrees.

I herewith append a comparison of the yield of the Semet-Solvay and the Bee-Hive systems:

Kind of coal coked.	Yield, Bee-Hive.	Yield, Semet-Solvay.
Connellsville	66 per cent.	72 per cent.
Pocahontas	62 per cent.	80 per cent.
Morris Run	60 per cent.	78 per cent.
Alabama coals	60 per cent.	72 per cent.

The Cambria Steel Company was the pioneer industrial concern and coke producer in the United States in the adoption and installation of by-product coking plant. As has been already mentioned, a plant of Semet-Solvay ovens was installed at the Dunbar furnace plant of this company at Dunbar, Pa., in 1895. At the same time the United Coke & Gas Company of New York, which concern controls the American rights of the Otto-Hoffman by-product oven, contracted with the Cambria Steel Company for the erection of a plant of sixty Otto-Hoffman ovens at Johnstown, Pa., and this plant was put into operation early the following year. An addition of one hundred Otto-Hoffman ovens has since been made to this plant and another is proposed.

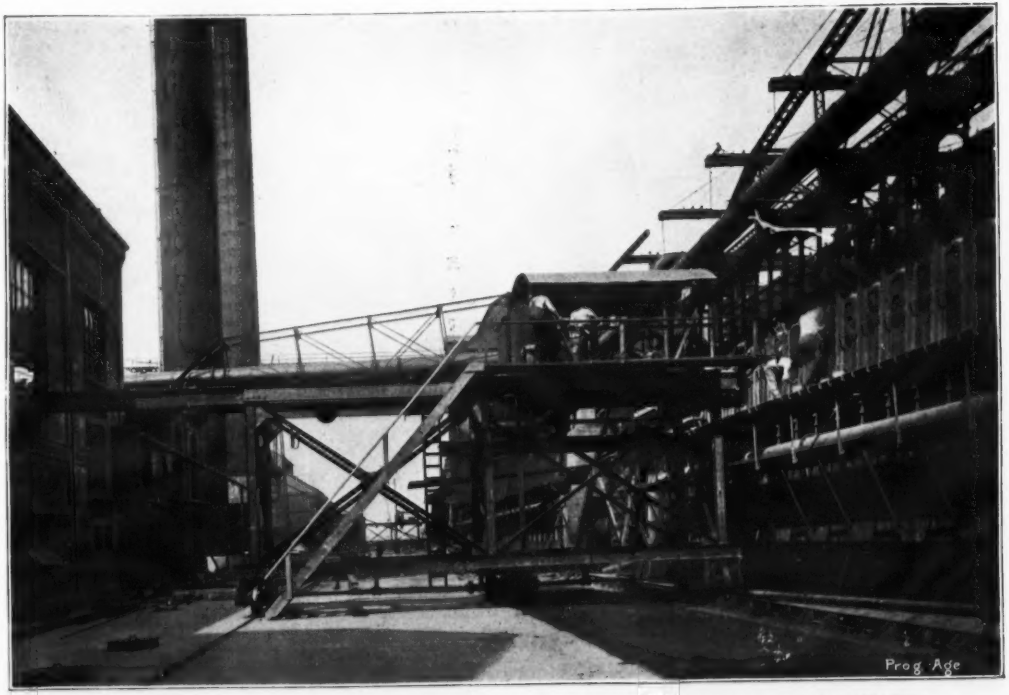
The Pittsburg Gas & Coke Company has installed a plant of one hundred and twenty ovens at Glassport (also called Otto) Pa., near

Pittsburg. For a time slack coal from the gas-coal mines of the Pittsburg district was used at this plant, and the coke produced was used in the furnaces of Pittsburg and elsewhere with excellent result. Owing to the inability of the company to obtain a sufficient supply of this slack coal, run-of-mine coal from the mines of the Washington Coal & Coke Company, located in the Youghiogheny coal fields, is now used at the Glassport by-product plant and the best quality of furnace and foundry coke is there produced.

The New England Gas & Coke Company has now in operation a plant of four hundred Otto-Hoffman ovens, and a large addition is now being planned, the original plant having been laid out for one thousand two hundred ovens. The Dominion Iron & Steel Company has now in operation a plant of four hundred ovens of this pattern, and at Hamilton, Ohio, the Hamilton Otto Coke Company is operating a plant of fifty of these ovens for the manufacture of foundry coke and illuminating gas. In addition to the above there are now under construction two hundred and thirty-two Otto-Hoffman ovens for the Lackawanna Iron & Steel Company at Lebanon, Pa., five hundred and sixty-four similar ovens for the same company at Buffalo, N. Y., and one hundred ovens of the same type for the South Jersey Gas, Electric & Traction Company at Camden, N. J., which brings the number of Otto-Hoffman ovens either in operation or under construction in the States up to two thousand and twenty-six. The two plants now being installed for the Lackawanna Iron & Steel Company will engage chiefly in the manufacture of furnace coke, the by-product recovery being a secondary consideration, while the plant at Camden will supply the cities of Camden and Trenton with illuminating gas and manufacture coke as a subsidiary industry.

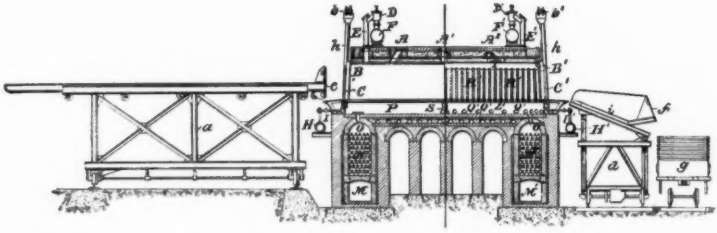
The Otto-Hoffman ovens are built in batteries, each battery forming one working unit. While this type of oven varies in dimension to suit required conditions, the standard is 33 feet in length, 6 feet in height, and in width varies from 16 to 22 inches. They take a charge of 6 to 7 tons to the oven, and the finished coke is discharged by means of automatic pushers. Electrical charging machines are employed and the coal is leveled in the ovens by means of scrapers. The heating system of this type is based upon the Siemens regenerative principle. The ovens are built with thirty-two vertical flues, sixteen in each of the side walls.

The coke-oven gas, freed from tar and ammonia, is partly sent back to the ovens, and from the fuel-gas mains tuyeres carry this gas on either side of the oven into the combustion chambers, the gas being



COKE PUSHER AT A BATTERY OF OTTO-HOFFMAN OVENS, NEW ENGLAND GAS & COKE COMPANY.

introduced alternately at each side, during which time cold air is blown into the bottom chamber of the regenerator in order to pass upward through the checker work which has been previously heated to a high temperature. The hot air is then introduced through the porthole into the bottom flue of each oven, and from there it passes through small openings into the adjoining chamber where the combustion of the gas takes place. The air supplied to the gas flame has a temperature of 1,000 degrees centigrade. The products of combustion are expanded in the bottom chambers until their course is checked by partition walls, when they rise through the vertical flues on one side and descend through the corresponding flues on the other side. Then they pass into a gas chamber and thence into the bottom flue and through the porthole into the regenerator. The heat remaining in the gas is stored up in the checker work of the regenerator, and from there the

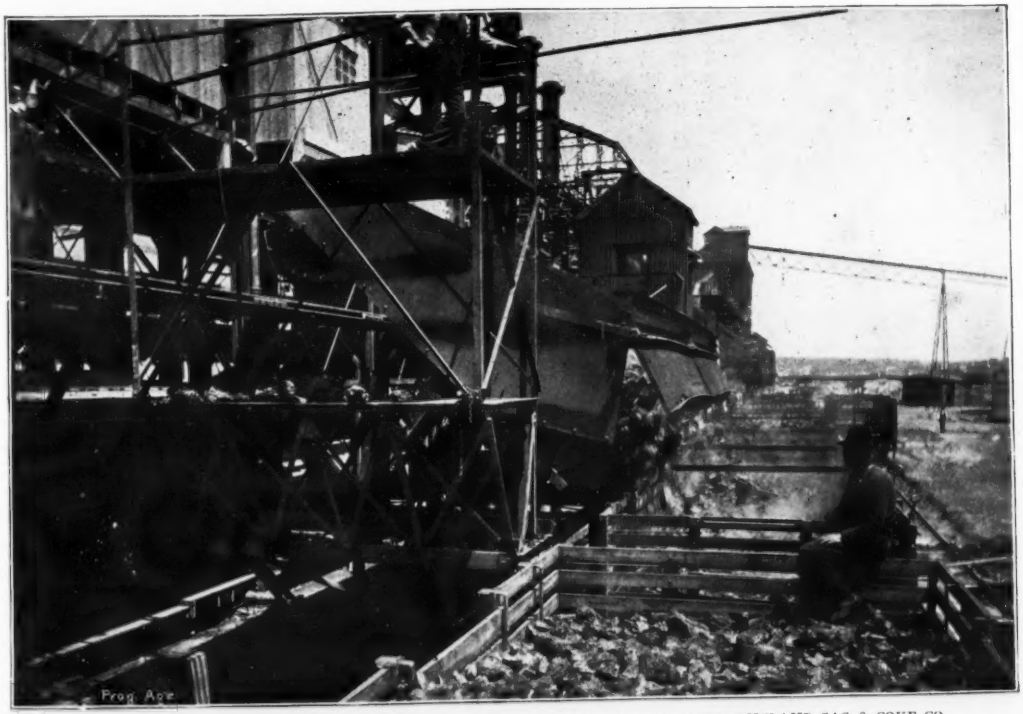


SECTION THROUGH OTTO-HOFFMAN OVEN WITH PUSHER, COKE LOADER, AND CAR.

gases pass through a flue to the boilers and thence escape into the stack. While one generator is thus being heated the other has been cooled by the pre-heating of air and, by a valve, the gas is reversed every hour or so. At the different plants of the Otto-Hoffman system numerous tests as to the economy of the regenerative system of firing have been made, and for the system its numerous advocates are in a position to demonstrate a decided economy.

Coke produced by the Otto-Hoffman by-product system possesses many merits over bee-hive-oven coke, and the same is true of coke produced by any of the by-product coking systems. The average analysis of the coke produced at the Glassport plant of the Otto-Hoffman system gives: volatile matter, 1 per cent.; fixed carbon, 86.47 per cent.; ash, 11.57 per cent.; moisture, 3.17 per cent.; sulphur, 0.96 per cent.; phosphorus, 0.0107 per cent.

Something regarding the recovery of by-products by the Semet-Solvay system has already been given. The construction of the by-



COKE LOADER DISCHARGING A BATTERY OF OTTO-HOFFMAN OVENS, NEW ENGLAND GAS & COKE CO.

product apparatus in the various systems may differ materially, but the processes by which by-products are recovered and converted to the uses of modern industry differ but little, as do the results obtained. Without regard to any particular type of retort oven, it is now quite generally accepted by fuel users that the retort-oven coke is superior to the bee-hive-oven product, the coal coked being of the same character. The gain in production by the new systems runs from 10 to 40 per cent. The cost of a Semet-Solvay or an Otto-Hoffman oven equipped with by-product-recovery apparatus can be placed at from $2,500 to $3,000. Either type is considerably larger than a bee-hive oven; the percentage of coke yield is much greater; and the by-product utilized brings the efficiency of either pattern of the by-product oven up to four or five times that of the bee-hive oven, while the durability of the new type of oven is such as to add greatly to their advantage. By-product-recovery apparatus is also adaptable to the regular bee-hive oven. At Pocahontas, Va., a plant of fifty-six bee-hive ovens have been converted into a modified type of Newton-Chamber retort ovens. The Newton-Chamber oven much resembles the bee-hive oven. At Latrobe, Pa., the Latrobe Coke & Coal Company installed a plant of thirty ovens, but they have been out of operation for some time.

The primary products recovered from the coking of coal are coke, fuel gas, ammonia, and tar. In the bee-hive oven all of these save coke are a complete loss. In the by-product coking system a portion of the gas is consumed for heating the ovens in the coking process. The surplus fuel gas can either be converted into illuminating gas, or used for power in gas engines or for other purposes where fuel gas is required. The amount of gas evolved from any coal is proportionate to the volatile matter contained in the coal and the heat to which the coal is exposed during the coking process, or in the extraction of the component gas. In a coal like the Connellsville coking coal, containing from 29 per cent. to 35 per cent. of volatile matter, there are from 8,000 to a little over 9,000 cubic feet of gas per short ton. On this basis the 30,000,000 tons of coal coked in the United States last year would produce more than 250,000,000,000 cubic feet of gas. Allowing one-half of this production for consumption in the oven, we have remaining over 120,000,000,000, or about one-half the annual natural gas production during the height of that excitement. To convert this fuel gas into illuminating gas involves a change in the operation of the oven so that gas produced with the recuperation of air and gas may be burned in the flues instead of the rich coke-oven gas.

Ammonia, that is ammonia sulphate, is the most valuable of the

by-products of coke making, it having a market value of about $20 per ton. The yield of this by-product from each ton of coal coked is about 20 pounds, or a total yield of over 300,000 tons for the 30,000,000 tons of coal coked in the States last year, which would make the value of this by-product over $6,000,000. The yield of tar is about 60 pounds per ton of coal coked. By-product tar is superior to tar that comes from the gas works. It contains a less amount of pitch, and its fuel value is about $5 per ton, which would give a value of nearly $5,000,000 for this product from the coal consumed in coking last year. In their primary state the combined by-products of coke making have a value of close to one dollar for each ton of coal coked.

However, we can add to the $30,000,000, which represents the value of the by-products which would be saved by the new coking systems, the gain of 15 to 20 per cent. in coke production which they make possible; we can also estimate the saving in operation, the gain from durability of construction, and the economy in the way of improved equipment, and thus obtain the sum total in favor of the new coking systems. Since the introduction of these new systems into America less than ten years ago over four thousand of these ovens of various types have been put into operation, and their success has been such as to insure their rapid growth and the future predominance of these ideas. Time will come when economy will be a necessary factor in coal matters in the western continent, just as it is in England and in continental Europe at this day.

The by-product systems of coke making are destined to shift the coking industry to the manufacturing centers and to the points of coke consumption, where they will undoubtedly find their greatest development. Already a number of these plants are in operation at the iron and steel manufacturing centers in the United States, and furnace and foundry owners are now giving the by-product-coking question much consideration. With such plants in operation in the manufacturing centers the "excess gas" can be readily utilized for industrial operations, either for furnace or foundry operations or for the generation of steam or gas-engine power, this innovation enabling the operation of such plants on the most economic basis. Coal is much heavier than coke, but can be shipped in almost any kind of cars; and this departure in coke making possesses many advantageous features. The by-product coking systems are also receiving favorable attention in connection with the abatement of the smoke nuisance in cities, and other new opportunities are being opened up by these new ideas.

OPPORTUNITIES FOR BETTERING THE WORK OF THE FOUNDRY.

By Percy Longmuir.

Comment has been made previously in this Magazine upon the relative backwardness of the foundry in the matter of adaptation to economical production. It is the more strange that this should be allowed to continue, because imperfect castings mean more work and more expensive work in the shop, where low cost of production is now a matter of the closest study. Mr. Longmuir sketches broadly conditions as they too often are, and as they might be to the advantage not only of the foundry itself, but of the workshop to which it furnishes materials of construction.—THE EDITORS.

ULTIMATELY, the aim of any foundry is to turn out good castings in an economical manner, and the success of the foundry is or should be based on the final cost of the finished castings. Any reduction of this cost, either in the foundry or by turning out castings in such a manner that less after treatment is required to bring them down to working conditions, is to be welcomed. The condition of the metal in a casting, the method adopted in its production, and its requirement of the maximum or minimum of machining, are strong factors in determining economy; and in these three items alone a wealth of opportunity to increase the efficiency of a foundry may be found.

Circumstances have compelled the recognition of these facts in British speciality foundries, this recognition crystallising out into more or less definite systems of working and organisation and an acknowledgement of mechanical aids and labour-saving devices. But though recognised in the speciality establishment, these matters in the general foundry do not receive the attention warranted by their importance. A vast field of undeveloped opportunity for the general founder lies immediately to hand. Imagine for one moment the extent of this far-reaching field of opportunity, which includes the many foundry operations, materials, tools, etc., various aspects of metallurgy, and types of melting furnaces. Compare this with a similarly extensive field in any other industry, and contrast the number of patents or recent inventions with those in force in the foundry world. Of the few inventions acknowledged in the latter sphere, many are the offspring of non-founders. There are several reasons

for this, chief of them being the fact that in many cases special tackle and methods have to be designed for the production of only one casting. Hence founders get into the way of quietly accomplishing any difficult work on hand, and the particular method adopted becomes buried in the archives of their own foundry. It must also be confessed that founders as a rule do not get much encouragement for the development of original methods.

Frequently on the same establishment may be found a machine shop or kindred department fitted with every modern appliance that scientific engineering can devise, and a short distance away a foundry in which everything is noteworthy for its hoary antiquity. Further, these contrasts are not by any means exceptional; they may be seen in many engineering centres. The introduction of mechanical aids or of new methods into the foundry is carried out in far too hap-hazard and unsystematic a manner. A common example is that of a moulding machine; purchased by a member of the firm whose information on foundry matters is supplied by the seller of the machine, it arrives in the foundry almost unannounced and it may stand for some time until a place can be cleared for it, and then be stowed away in some odd corner and given a half-hearted trial.

If these conditions really exist—and few will dispute them—the matter of pointing out foundry opportunities will hardly be a difficult one; the difficulty will rather be in keeping to general ones, for each individual foundry must possess its own separate opportunities.

In the following remarks on iron, steel, and brass foundries, an effort has been made to view each case from a different point of vantage; but though differently treated, conditions in each foundry tend to merge into one another and successful methods in one case may be adapted to meet similar conditions elsewhere. It is in this light that the remarks on iron-foundry conduct must be viewed, for successful methods in iron moulding, after adaptation to local requirements, will meet with the same measure of success in the brass foundry.

With copper fluctuating between £68 and £74 and tin from £120 to £140, it is hardly necessary to say that in the brass foundry the matter of metal and melting are the first considerations. Add to these the cost of fuel, crucibles, wear-and-tear of furnaces; and the price of molten metal per pound may be anything between 5d. and 10d. according to the quality of the alloy. Any opportunity of reducing cost in this direction is therefore worth examination. The first item under this head is naturally that of prevention of loss of metal, which loss may occur in many ways but we will take three as typical:—

(a) Loss by volatilisation.
(b) Loss as shot metal, spillings, fires, etc.
(c) Loss in the ashes.

(a) The loss by volatilisation can hardly be totally prevented, but by intelligent melting and handling this loss may be greatly decreased and by efficient supervision kept normal.

(b) When casting, much needless loss of metal occurs by careless skimming—that is, raking of metal with slag, careless pouring, as spilling metal outside the "gate," filling too full, causing overflow on to foundry floor, and strained castings. It is quite possible that this metal will all be gathered up again, but hardly probable. There is the loss of melting, the labour of collecting and freeing from iron, etc., and the uncertainty as to spillings getting back to their respective qualities again. Indeed, to prevent confusion many foundries adopt the system of classing all the spillings with the commonest metal. That this does not trend toward economy will be shown subsequently in the case of borings.

(c) Brass-foundry ashes are of course always sold, and before leaving the works they may be cursorily looked over and any large pieces of metal picked out; in this condition they will realise from 15 shillings to 18 shillings per ton. Carefully picked and washed, the refuse will still sell for anything between 7 and 10 shillings per ton and the scrap metal obtained from this picking and washing fully justifies the adoption of such a plan.

The treatment of brass turnings and borings offers golden opportunities for systematic and economic handling. The general plan is to deposit all the turnings from the machine shop into one bin, pass them through a magnetic separator, and melt them down with the aforementioned spillings, trimmers' scrap, etc., into ingots. The ingots are generally used for the lowest quality of castings, or at the best only in admixture to give a second or third-quality alloy. An undeserved stigma is attached to these borings; engineers will not recognise their value, and, as just stated, borings worth 10d. per pound are indiscriminately mixed with others whose value may not exceed 5d. A system of classification will meet that supreme test of all industrial operations "does it pay?" and meet it well.

Assume that the output be such as to give a return to the foundry of 15 hundredweight of borings per week; assume the value of these to be 10d., 8d., and 6d. per pound respectively, and also that equal quantities of each quality are produced. Under the conditions pres-

ently existing in many establishments these borings, mixed together and remelted in the foundry, would be valued in the form of ingot at 6d., or a total of £42.

If classified into their respective qualities:—

5 hundredweight	at 10d.	per pound.....	£23	6	8
5 "	" 8d.	"	£18	13	4
5 "	" 6d.	"	£14	0	0
			£56	0	0

or a difference of £14.

The melting down in either case will be the same, and against the £14 there is the cost of classification, which should in no case exceed £2, leaving a clear gain of £12 on 15 hundredweight of borings. That the cost of this classification should not exceed £2 may be gathered from the fact that one handy-man can collect the borings from the machines before a change of work or different quality of metal is put on. Copper and white-metal borings or turnings are in the same manner taken away from each machine before changing work. The same man passes the borings through a magnetic separator and takes them to the foundry storage bins. In the foundry these borings are melted down as occasion serves, say in 2-ton lots in the air furnace, and the ingots used again in their respective qualities. The trouble expended on such a classification is fully and financially justified.

Many white metals used for lining-up bearings contain a minimum of 85 per cent. tin. These turnings, when separated, can be profitably used as a means of adding tin to an alloy, and alloys so made up give in practice good results. The dross and skimmings of the white-metal shop present another opportunity. This dross may be readily reduced at a white heat by means of charcoal and sodium carbonate, and will yield as much as 70 per cent. of metal consisting chiefly of tin and copper, with small amounts of antimony. If anti-friction metals containing lead are used, more or less lead will be found in this recovered metal. It is best worked down in fairly large quantities to obtain uniform batches, analysed, and subsequently alloyed with the necessary copper and zinc to make up a fair gun metal.

These examples are actual possibilities and they merely indicate in a practical manner the vast opportunities for intelligent and profitable application of metallurgical knowledge as connected with the alloys. Borings and turnings, slags, oxides, and ashes and even the very sand heaps of a brass foundry all offer problems that will yield profitable solutions.

What are the opportunities that lie within the grasp of the general iron foundry? Unlike the brass foundry, the metal is not the chief item; and though by methodical and intelligent mixing this can be considerably improved, it is obvious that the greater opportunities lie in the method of handling it, in the form of pig and when molten, in the methods of moulding, and in general foundry operations. Nothing unduly "ideal" or "classic" is here intended, and as evidence of this I will take as examples two typical iron foundries such as may be seen in any foundry centre in Britain and describe in part their working conditions.

1. A jobbing iron foundry, output 20 tons per week, consisting of a few specialities, builders' and street-drainage work, and general castings for the trade; heaviest casting about five hundredweight. The specialties are moulded from plates or in snap flasks. Cast-iron boxes are used for the plate moulding, joints not planed and hence seldom true; cast guides serve as pins and these are just as they have left the sand. It is no small wonder, then, that castings showing overlapping joints and varying in weight and thickness are made from the same plate patterns. The snap flasks are fairly good, but this is owing to the fact that necessity compelled their purchase from outside makers. The only work made in these flasks is of a simple and shallow character, nothing deep being attempted. In the general moulding boxes no apparent design can be detected; suitable patterns were not made to mould them from and they possess a hap-hazard "fit where they touch" sort of look. The moulding tools are on a par with the boxes, and necessities such as brushes, bellows, pails, rapping bars, rammers, shovels, etc., are noteworthy by their comparative absence. The sand mill is a relic from a dismantled mortar-grinding establishment. The cupola, also a second-hand bargain, is fitted with two tuyeres and the charges are carried onto the stage by hand. This may be a little out of date, but then the cupola was picked up dirt cheap, and though it may burn a little extra coke that item does not count for much in the long run; and as for carrying up the charges—well, unskilled labour is cheap enough anyway. Possibly!

A moulding machine is installed but not operated. The preliminary expense of this machine was met with pleasure, but the necessary accessories were fitted up on the cheap system. Moulding boxes were good enough without fitting, plates would answer quite well without any expensive machining up, and therefore the handy-man of the establishment prepared both the boxes and plates. This machine now stands in "icy isolation," a superb monument to the folly of the cheap

system. The arrangement of the foundry is in keeping with the tools—no mechanical appliances of any kind, and every ounce of metal, every lift, is carried or performed manually. Boxes are stacked anywhere and generally in the most inconvenient places. Foundry supplies are equally inaccessible, and the moulders spend no inconsiderable time in searching for material. Add to this the fact that one end of the shop is open to all the winds of heaven, that coke, iron, scrap, sand, ganister, limestone, boxes—all form a hopeless chaos at this open end (which serves the double purpose of store yard and entrance) and we have a picture with a very telling moral. The method of working is equally hap-hazard; the moulds are slovenly made, put down in any corner that strikes the man's fancy; hence all classes of work are indescribably mixed and the appearance of the floor just before casting time is one of bewildering confusion.

The example quoted is not that of a foundry suffering from want of capital, nor yet that of an establishment making no profit, and many similar instances may be found amongst the jobbing foundries. If profits are made under these slothful conditions—and they undoubtedly are—then a most magnificent opportunity lies already at hand to increase these profits manifold. The immediate renovations in this particular establishment might be thus tabulated:

1. The installation of a quick-melting cupola, a blower of ample capacity, and the charging stage served by a suitable hoist.

2. The division of the foundry into floors suitable to various classes of work, and the equipment of each floor with the requisite tools and equipment to mould and produce clean, sound, economical castings.

3. Serving these divisions by a narrow-gauge track, the moulders on each floor taking their supply of molten metal from a "bull" ladle carrying molten metal along the tracks and supplying each section.

4. The adoption of convenient moulding boxes efficiently mounted and fitted complete.

5. Systematic group storage of these boxes in such a way that any one can be reached expeditiously. Neat and convenient storage of all foundry materials—the aim being to economise time and space.

6. Methodical management, powerful organisation, and the development of mechanical aids in moulding the speciality castings.

As a second example, a typical engineering foundry employing fifty moulders will be selected. This particular foundry is engaged in general engineering work and fairly good castings are turned out, but to get them costly and unsystematic methods are resorted to. On the cupola stage charges are not weighed, consequently the product is sel-

dom uniform, and as hardness tests are not made nearly every cast varies, as the machine shop will testify. As in the first example, there is here a lack of system on the moulding floor. Loam, dry-sand, green-sand moulding, and core-making are mixed up to an unfathomable extent. To emphasise this further it may be stated that each moulder orders his own cores. It frequently happens that the cores are forgotten until the mould is made, and therefore cannot be finished until the cores are dry. If this happens near casting time, half-dry cores are put in and in the necessary rush vents are forgotten and the cores improperly fixed or centered. In order to get the top sides of castings to machine up clean, they are thickened to as much as half-an-inch above pattern size. The additional work thus thrown on the machine shop is not at all justifiable or in keeping with the spirit of modern founding.

Although many standard pieces are worked year in and year out, no plate moulding is adopted and mechanical aids to moulding are deemed unworthy of attention. The tools are scarce and inefficient, the stock of boxes being only sufficient to supply twenty-five moulders instead of fifty; hence many devices have to be resorted to in order to keep the men going. Boxes are split up—a top part to one, a drag to another, and so on. Patterns made for rolling over are bedded in the floor, and the best thing that can be picked up is used for a top part. This entails much cutting of bars, making of hangers to carry the sand, and an all-round addition of work and risk. This state of things is owing to the fact that the establishment in question is too busy to make any boxes and this has been the case for several years. There is a similar scarcity of general tools—this foundry in common with many others suffering from the absence of all system in storing either tools or material. One result of this lack of organisation is that a large amount of overtime is worked, by no means tending to economy.

Under this latter head may be found the weakness of this particular establishment—poor organisation. To remedy this, put the organisation and management on a footing in keeping with modern industrial progress, and an opportunity has been embraced that will materially affect improvements in quality of product and reductions in cost. No elaborate system is advocated, simply intelligent management, methodical division of work on the moulding floor, and systematic mixing on the cupola stage.

The advantage of an application of metallurgical science and the possibilities and benefits to be derived from an effective organisation have been dealt with in the brass and iron-foundry sections respec-

tively. These opportunities, after adaptation to local requirements, apply equally to the steel foundry, special opportunities lying in the direction of increasing the reliability of cheaper or non-tested grades of castings, better designs of drying stoves and annealing ovens, and the introduction of sands and facings to resist the high temperature of steel and to give smooth, clean castings. The stringent specifications steel castings have to meet tend to keep the quality of tested castings ever on the upward grade. If the same care were devoted to the mixtures and melting of steels for non-tested castings as is shown to specification and forge qualities, then one cause of unreliability and failure in working life would be removed. It must be confessed that certain so-termed cheap qualities of steel castings are decidedly inferior, and in practice give results lower than, or at any rate, no better than would be obtained from malleable cast iron.

Steel mixing and melting demands the exercise of extreme care. This is recognised and met in a way that should convey a very telling object lesson to the iron and brass founder. In steel-foundry practice, the chemical and physical laboratory are recognised institutions and every advantage is taken of scientific assistance. Crucible-furnace mixtures are controlled and regulated by chemical analysis; the same factor controls the working of the open-hearth plant, and supplies with each cast a complete chemical analysis—that is to say, the content of carbon, silicon, manganese, sulphur, phosphorus and (differentially) iron in the product. This chemical control of composition, in combination with various mechanical tests of the material, keeps an efficient check on the quality and materially assists in the economical production of good castings.

The high initial casting temperature of steel necessitates the use of special moulding materials, and in this direction lies a large field for experiment. Naturally, a highly refractory material is required—one that will give a smooth and even skin and at the same time peel readily from the castings, in a similar manner to the way in which the facing sand peels from an iron casting. All moulds for steel castings, with the exception of those of light section, are stove-dried. In the matter of these drying stoves much improvement can be effected, for many of them seem to have been built with the sole idea of consuming fuel only. The design of a drying stove should be such as to dry quickly, thoroughly and economically,—conditions not hard to meet.

Steel founding offers fair scope for the development of machine and plate moulding, many articles, as for instance spanners, being of a repeat character. Other opportunities lie in the direction of adopting

systematic methods in overcoming the effects of warping, piping, contraction and kindred evils.

From what has already been written it will be readily gathered that the greatest of all immediate opportunities lies in more intelligent and systematic organisation and management. The work of the foundry must not be unduly increased in order to save the expense of a few tools. On the other hand, there must be no needless accumulation of boxes, etc., of no further use than to fill up storage room. In this, as in all other cases, an endeavour must be made to strike the happy medium and to obtain the highest degree of efficiency at a minimum outlay. Subdivision of work has been spoken of, but yet further word may be permitted on this head. A moulder is profitable only while moulding, and therefore the aim of any system should be to save him all labouring or unskilled work, thereby benefiting the moulder personally and the foundry generally. This may be done by the judicious employment of trained labourers to knock out the boxes, prepare the sand for the moulders, and handle all materials and flasks. An extension of this principle results in the employment of a casting gang, a strong endeavour being made to keep the moulder at his legitimate business of moulding exclusively.

The equipment should be such as to occasion no waiting or searching for tools or materials. These conditions can be readily secured by the exercise of that invaluable industrial commodity—forethought. A good system of foundry stores, in conjunction with the plan of making the men responsible in a pecuniary sense for the tools entrusted to their keeping, will materially assist in effecting this result. The general equipment must be arranged to meet the particular need of each individual foundry, and this subject is one that will repay any amount of time and thought expended on it. Economical and efficient furnaces, ample power for handling boxes, metal, etc., and good facilities for the quick production of all classes of castings are a few of the essentials under this head. The metallurgical opportunities have been indicated in the remarks on brass-foundry practice and give full evidence of the advantage to be derived from a thorough application of metallurgy to all foundry work. The present position of chemical analysis in steel works is an indication of what the future holds for the iron and brass founder.

The opportunities here presented doubtless savour of the moulding floor and the sand heap, but experience firmly convinces that a proper management of that floor and suitable use of the heap results in large increase of efficiency and profit.

THE COPPER MINES OF ASHIO, JAPAN.

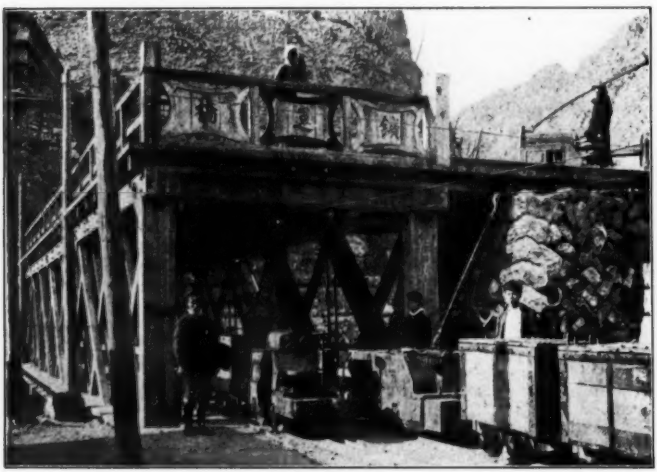
By Edwin G. Adams, Jr.

SINCE Japan abandoned its policy of isolation, under the instigation of Commodore Perry's fleet in 1853, the whole world has stood amazed at the rapid development of its latent resources; and in no industry has this development been more apparent than in that pertaining to mining. The gold and silver mines of the Island of Sado, the coal mines of Moji, the sulphur mines of the volcano of Atosa-nobori, and the copper mines at Ashio, have all been worked, according to authentic record, since earliest times by the primitive native methods; these have now given place to modern metallurgical appliances operated by native mining engineers educated in Japan.

The abandoning of the old methods has had its natural effect on the output of the mines of Japan; all metals, with the exception of iron, show an increased production since the beginning of the period of transition which may now be said to have reached its end. This increase is particularly well-illustrated by the statistics giving the annual output of the copper mines. In 1881 they produced 4,810 metric tons;

AN ADIT OF THE ASHIO MINES.

10,625 tons in 1885; 16,384 tons in 1889; and 19,814 tons in 1894,* and since then the production is said to show a still further increase, but no statistics are available. This output places Japan next to the United States, Spain, Portugal, and Chili as a copper producer. About one-third of this total is the product of the Ashio mines, which rank high in the list of the world's great copper producers. The Ashio mines were originally the property of the Japanese Government, and have been worked since the sixteenth century with an annual output



ELECTRIC LOCOMOTIVES WITH ORE CARS.

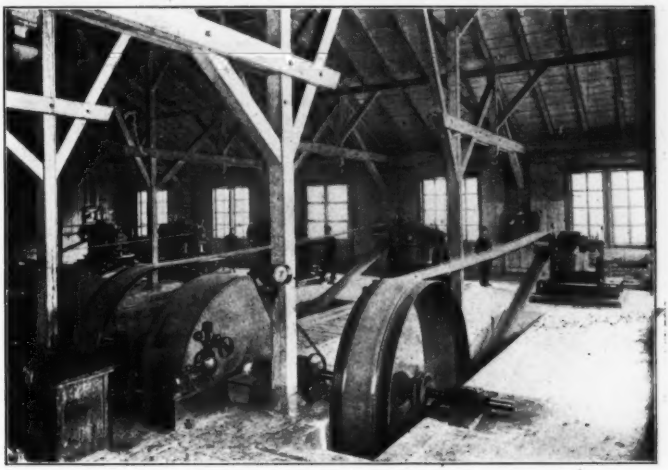
never exceeding 300 tons; they are now owned and operated by Mr. Furukawa Ichibei of Tokyo, and under his efficient management the output has been largely increased until it has now reached the remarkable figure of 6,000 tons per annum.

The mines are situated 10½ miles south-west of Nikko, a place that few globe-trotters fail to visit, for here is located the most perfect assemblage of shrines in the whole land, combined with noble mountains, cascades, and monumental forest trees. The journey from Tokyo, or Yokohama, is made by train, the 91 miles taking most of one day, and the trip to the mines can then be made directly from Nikko by jinrickshaws. If the tourist is visiting Chuzenji (and this beautiful mountain lake is seldom omitted from the itinerary of the most hurried worshipper at the shrines) the inspection of the mines may be made on

* *Résumé Statistique de l'Empire du Japan, Tokyo, 1895.*

the return trip to Nikko; but this route is available only to pedestrians, as the path down the pass is cut out of the cliff sides or supported on plank bridges. Tea houses along the route exhibit beautiful specimens of copper pyrites, which are sold to the Japanese pilgrims on their way to the sacred mountain of Nan-tai-san overlooking Lake Chuzenji; and the traveller is also notified of his proximity to the copper mines by the tram cars passing through the street of Nikko, drawn by slow-moving bullocks, laden with copper ingots on the down trip and returning with fuel.

The change of scene from Nikko, or Chuzenji, is complete. One leaves a land of peace with delightful surroundings and steps into the midst of a foul-smelling, smoke-laden valley where the bare red hill-sides, denuded of all vegetation, present a striking contrast to the green hills at Nikko, with its world-famed avenue of cryptomerias,



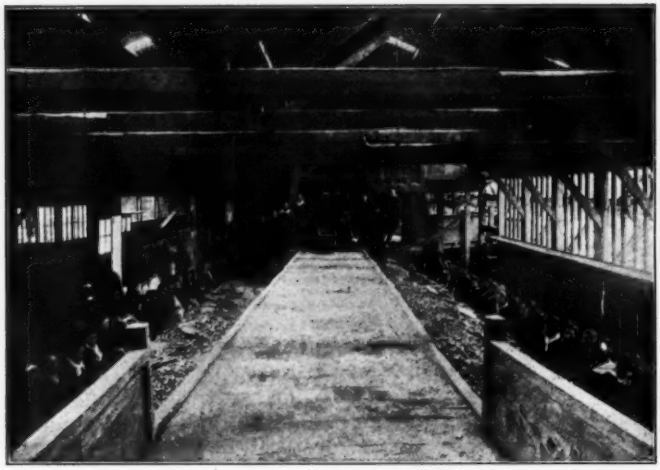
INTERIOR OF THE POWER PLANT.

while the air vibrates with the clang of hammers and the throb of engines.

The mines are worked by adits located at the villages of Ashio and Kotaki; the former is the more important and is situated on the eastern side of the mountain, the latter on the western, but the two are generally spoken of collectively as the "Ashio Mines." The adits from the Ashio side are being pushed forward to meet those working from Kotaki, about 2½ miles distant, and at the present rate of working the mines will be exhausted in about ten years.

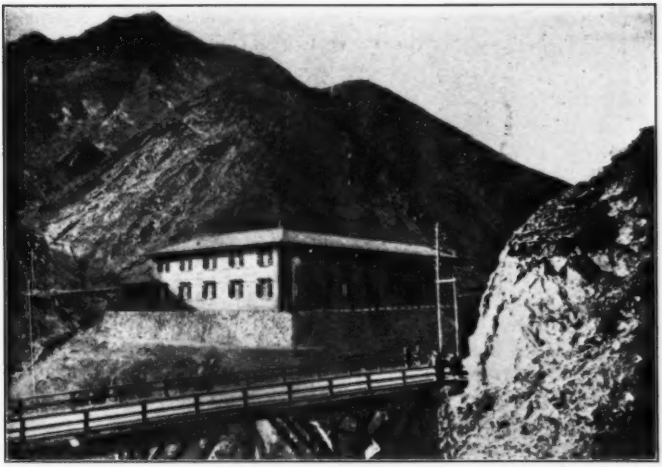
The village of Ashio, where the operatives have their homes, is separated by the Watarase-gara, a mountain stream running between steep banks, and spanned by numerous bridges, carrying the tramway and flumes. No two of these bridges are alike in design; in fact, it would seem as if the bridge engineer of the works had put into practical use all the available literature on bridge designing.

The total number of persons employed in various services at the mines and furnaces is about 10,000 and these with their families make up a small city of 17,000. Of these 75 per cent. have been born on the spot, as were their fathers and grandfathers, and some have never seen beyond the red hills which close in the village and mines. They are



WOMEN SORTING ORE.

cared for by the proprietor, fed, and sent to school until twelve years of age. The village has a well-equipped hospital at which the operatives and their families are tended without charge. Only men are employed below ground to dig the ore, working in shifts of eight hours each, while those employed at lighter tasks work shifts of twelve hours. Women are employed at the light work, such as sorting and washing ore by hand, most of them being the wives of the miners. The average pay per day for those engaged in manual work is 13 cents in silver money and a stated quantity of rice and fuel, while the miners are paid by the quantity of ore extracted. The furnace and shaft men receive from 11 to 30 cents per day, and the women are paid 7 cents.



THE HOSPITAL.

The ore is almost entirely copper sulphide, although a small quantity of the oxide is also present, and it is worked from twelve veins from 3 to 6 feet in thickness. It carries about 19 per cent. of the metal, and the total output of sorted ore is about 100 tons per day. The treatment of the ore is as follows: The ore is sorted at the mines and divided

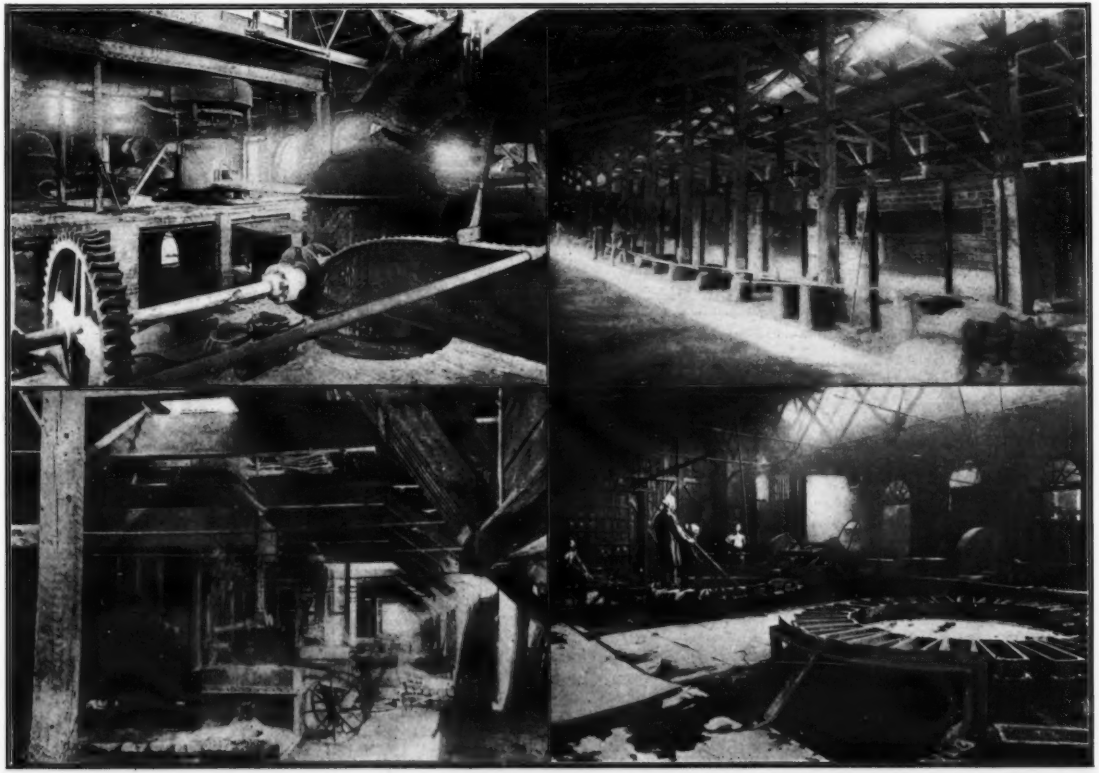
THE SCHOOL ROOM.

into two classes, the rich and the poor; the former is sent to the concentrating works, while the latter is resorted, crushed, and concentrated to bring it up to the same grade as the rich, after which the treatment is the same. This work is mostly done by machinery of German manufacture, although hand washing done by the women is still in use. The ore is roasted in brick reverberatory furnaces in which wood is used as fuel; it is then passed to the smelting furnaces, which are rectangular charcoal blast-furnaces, each having eighteen tuyères, constructed of wrought iron and protected by water jackets. The charcoal is made in the mountains close by by native burners, and is mixed with a small quantity of coke brought up from Nikko on the tramway. The flux—limestone—is obtained at quarries in the vicinity.

EXTERIOR OF CASTING HOUSE. IT IS BUILT OF SLAG BRICKS.

The product of these furnaces is black copper with a considerable amount of copper matte, assaying about 55 per cent. The black copper analyzes: copper, 96.014; arsenic, 1.226; iron, 1.361; tin, 0.692; lead, 0.428; sulphur, 0.337; bismuth, 0.112; silver, 0.014; cobalt, 0.012—total, 100.196.* The matte is broken up and remelted, after which it is put through a Bessemer furnace, each melt being 800 pounds, and the result is fine black copper which is said to be nearly pure. The copper is cast into rectangular ingots each weighing 58 pounds, rotating casting tables with cast-iron moulds being used.

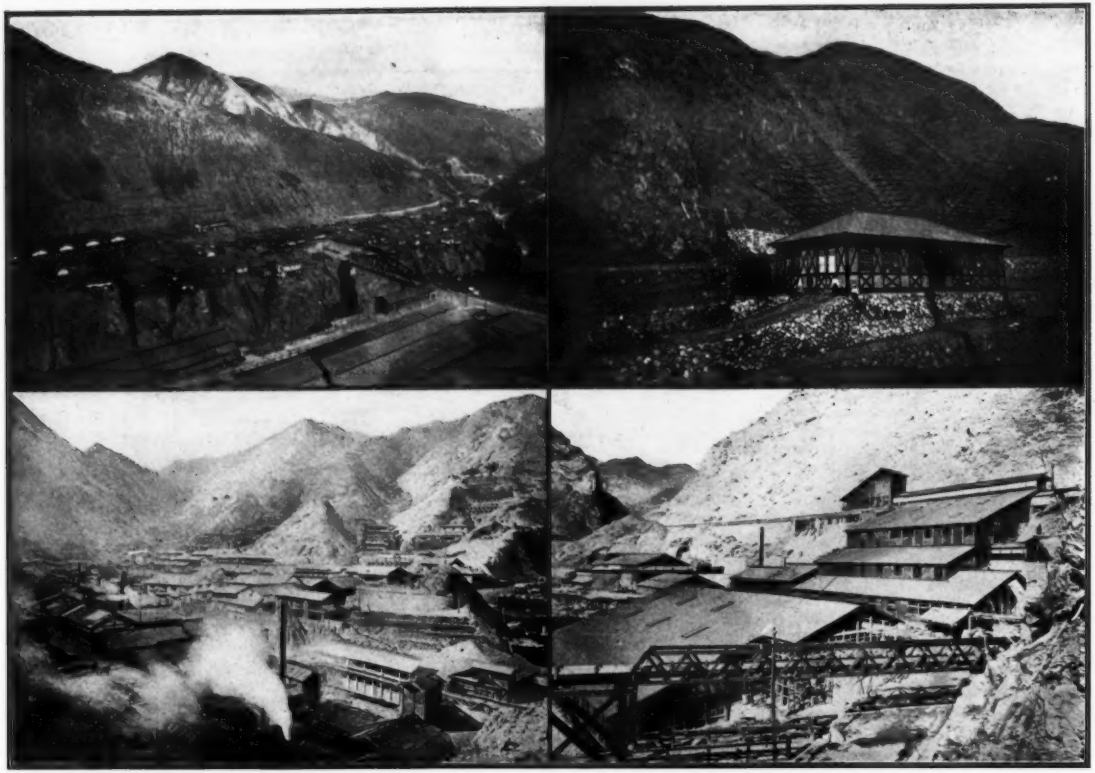
* *The Engineering and Mining Journal*, August 6, 1892, paper by Mr. W. J. Menzies.



Bessemer Plant for Copper Matte.
Interior of Smelting Plant.

The Roasting Furnaces.
Casting House, with Rotating Casting Tables.

VIEWS IN THE ASHIO COPPER-REDUCTION WORKS.

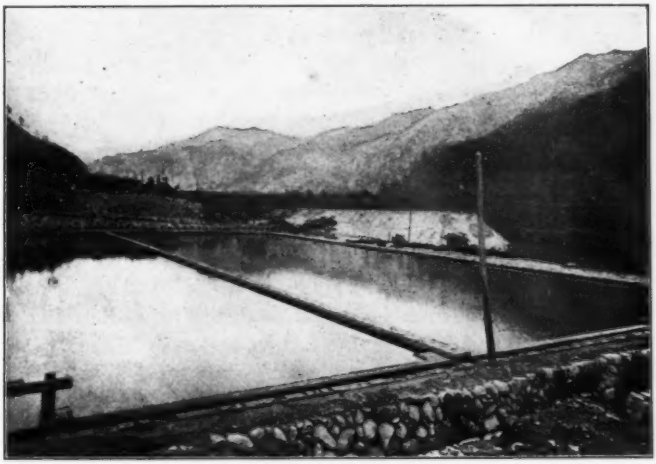


Village of Ashio. Part of Works in Foreground.
General View of the Works.

Protection Work on the Hillside.
General View of the Works.

THE ASHIO COPPER WORKS AND THEIR SURROUNDINGS.

Originally the water from the ore-washing plant, as well as the slag, was run into the Watarase-gara, but owing to the damage done by this poisonous discharge to the crops in the valley below, where the water is used for irrigating, and the subsequent agitation amongst the farmers living along its course, a series of settling tanks and filters have been fitted up for the purification of the water before it is allowed to enter the stream. Powdered lime is added to the water as it is run into the settling tanks, and after settling the water is filtered through sand beds. A large sum of money has been spent on this purification plant, and the result is said to be in every way satisfactory.



THE FILTER BEDS.

Another protection which it has been found necessary to inaugurate is the construction of basket work on the hill sides, on which there is absolutely no vegetation, to prevent the soil from being washed down into the village during the heavy rains which prevail during the months of July and August. This basket work is constructed of the small branches of trees twisted together and held in place by stakes driven into the ground; it has the appearance of a huge fishing net laid out on the hill to dry.

The river furnishes at all seasons an abundant supply of water, which is led by wooden flumes down the valley from the intake several miles above the works. One mile below the works is the power plant where 200 horse power is developed by Pelton water wheels and used for electric lighting of the village and works, driving motors, etc.

Electric-motor cars are used about the works and mines for hauling ore, etc. Thirty miles of narrow-gauge track is operated to Nikko, where the ingots are taken for shipment, and into the surrounding country for bringing in charcoal and limestone; but on this either the small native pony or bullocks furnish the motive power. Over the Hoso-o pass on the line to Nikko a cableway three miles long has been constructed, which consists of a steel-wire rope supported on wooden towers and revolving on cast-iron drums at each end. The load, consisting on the descending line of copper ingots and on the ascending of bags of charcoal and coke, is suspended from the cable by wrought-iron hooks which are fastened to the cable by wire bands. At some points the line is several hundred feet above the surface.

Low wages combined with abundant fuel and flux at hand permit the production at a moderately low cost. About 80 per cent. of the output is exported, China and Korea with their copper coinage being the largest customers, but it is brought into competition with American and European copper at Hong Kong, England, India, Australia, and Germany.

The mines are entirely under Japanese management and furnish an excellent example of the progress these people have made in the arts as well as of the willingness and ability of the native workmen to use new tools. The mine officials are most courteous to visitors furnished with proper letters of introduction, and the trip is to be recommended to those engineers contemplating a journey amongst the gentle Japs.

NOTE: The author wishes to express his obligation to those officials of the Ashio mines who kindly furnished him with the information which forms the basis of this paper and for the photographs used in illustrating it.

THE INDUSTRIAL APPLICATIONS OF NICKEL STEEL.

By Charles Edouard Guillaume.

One of the noteworthy subjects of the day in engineering work is the progress which is daily being made in the knowledge of alloys of various metals, and among these researches none has been more interesting than the work of M. Guillaume upon the nickel steels. The results of his investigations have formed subjects for important discussions of the French Academy, while apart from their interest to the student of pure science, they have found immediate and important practical applications. M. Guillaume here gives the results of his own original and noteworthy work, and makes some conservative predictions as to future extended applications.—The Editors.

THE present epoch, according to some writers, may be called the age of steel, and indeed we may follow the example of an earlier period, the age of stone, which was separated into the periods of chipped stone and of polished stone, and divide the present age into the period of carbon steel and the period of special steels.

There are many materials which have been systematically alloyed with steel to communicate to it the most diverse properties: chromium, manganese, tungsten, vanadium, aluminum, silicon, copper, etc., have been employed, but none of these has at the present time the importance of the alloy of steel and nickel. There are many reasons for this, of which we may mention the relatively low price of nickel, and the immense diversity of properties it is capable of communicating to steel.

For a number of years nickel steel has acquired celebrity because of its extensive use for military purposes. It might be considered desirable to give much space to the consideration of this phase of the subject, but it is so extensive, and also relatively so well-known, every popular journal having been filled with illustrations of armour plates and projectiles in all stages of resistance or demolition, that it has appeared more advisable to make a brief historical examination of the general subject of nickel-steel alloys, and then a more special study of the recently discovered alloys and their industrial applications.

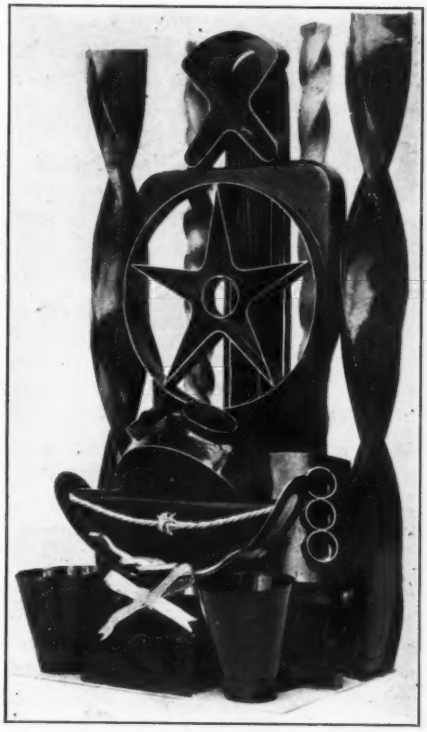
There is no definite record of the first attempts at the manufacture of ferro-nickel. Such alloys are by no means recent, however, for if we ignore the discovery of certain meteoric irons containing nickel in an imperfect state of alloy, we find in 1820 the first authentic traces of a rudimentary manufacture of some bars of ferro-nickel. Nearly a third of a century later there were exhibited at New York, by Mr. Thurber, a number of specimens of ferro-nickel, but it was not until another generation had elapsed that the true industrial importance of nickel steel began to appear. It was in the development of armour plate that nickel-steel first attracted attention, and for a time the superiority of the projectile was replaced by victories of the armour, although the development of modern high-power guns has again restored the superiority of the projectile. In this work the use of nickel extended to but very small proportions, the alloy acting to modify the properties of the steel without entirely transforming them. An addition of but 2 per cent. of nickel suffices to produce appreciable effects, and with the use of 5 or 6 per cent., or in rare instances to 10 to 12 per cent., the maximum effect in the direction of mere improvement in the steel for armour plate is reached. With further additions of nickel the phenomena at first become confused, and then acquire distinct peculiarities. As the proportion of nickel approaches 25 per cent. new properties appear, and as the nickel content is further increased these are again changed, the alloy departing further and further from the nature of steel, and acquiring properties which are both surprising and inexplicable. But before pursuing this subject further we must devote some space to nickel itself.

It was in 1751 that the Swedish chemist Cronstedt discovered nickel in a mineral which until that time had been worked for copper alone. For a long time it was produced in but small quantities, the supply coming altogether from the German and Norwegian mines, and it only began to assume industrial importance upon the discovery in New Caledonia by Garnier of the mineral which has been named Garnierite. A French company, formed in 1880 by Mr. John Higginson, began the development of the mines in New Caledonia, and the price of the metal, which had previously been about 25,000 francs per ton, fell to 5,000 francs.

Since that time the price has been somewhat lowered, partly because of the opening, in 1890, of the mines in Canada. The lowest commercial price in Europe has been about 3,000 francs per ton, but nothing is more significant of the increasing importance of the metal than the fact that the price has gradually risen in recent years more

than 30 per cent., in the face of a continually increasing production.

The most important producer at the present time is the French company "Le Nickel," of which the output has risen from 400 metric tons of 2,208 pounds, in 1890, to 4,000 tons in 1900. The English company "The International Mining Company" recently formed to re-work the mines already developed in New Caledonia, holds the second place. The Canadian mines, which in 1891 showed themselves strong competitors of the mines of New Caledonia, and of which the production rose in two years from 300 tons to more than 2,000 tons, will probably have some difficulty in maintaining their position when modern methods of mining, transport, and treatment shall have been installed in the great island of the Pacific.



SPECIMENS OF NICKEL-STEEL PRODUCTS.
An exhibit at the Paris Exposition showing the extreme ductility and toughness of the various alloys.

The ore found in New Caledonia is twice as rich as that of Canada, but the transport must be effected to the harbour from the mines on the backs of men, and the ore shipped to Europe for reduction. When, by the introduction of railway or cableway transport, the cost of handling shall be reduced, and the ore subjected to a preliminary treatment before shipment, we may expect that New Caledonia will become almost the sole source of supply of nickel for the whole world.

Let us now return to the study of the properties of nickel steel, properties so peculiar that Mark Twain himself might almost have invented them.

The first and most striking thing observed by the producers of nickel-iron alloys was the fact that with a ferro-nickel containing about 25 per cent. of nickel, two of the most magnetic substances known formed an alloy almost as insensible to the action of a magnet as copper. Since this combination almost completely nullifies one of the most characteristic features of both constituents it is natural to expect decided modifications of other properties. A still more singular fact appears in the discovery that the magnetic properties of the constituents may be conferred upon the alloy by subjecting it to great and rapid cooling. By the addition, however, of chromium, carbon, manganese, etc., the non-magnetic alloy may be rendered much more stable in this respect, so that it retains its properties, even after chilling in liquid air, or after the most severe mechanical treatment. We thus have a soft, and at the same time very tenacious metal, susceptible of a great number of useful applications.

Let us examine at more length this alloy, which attracted especial attention of metallurgists at the recent Paris exposition, and of which examples were shown by nearly all the important French establishments.

Tests made of these alloys, more or less modified by additions of other elements to be mentioned hereafter, but all containing about 25 per cent. of nickel, give the following average results:

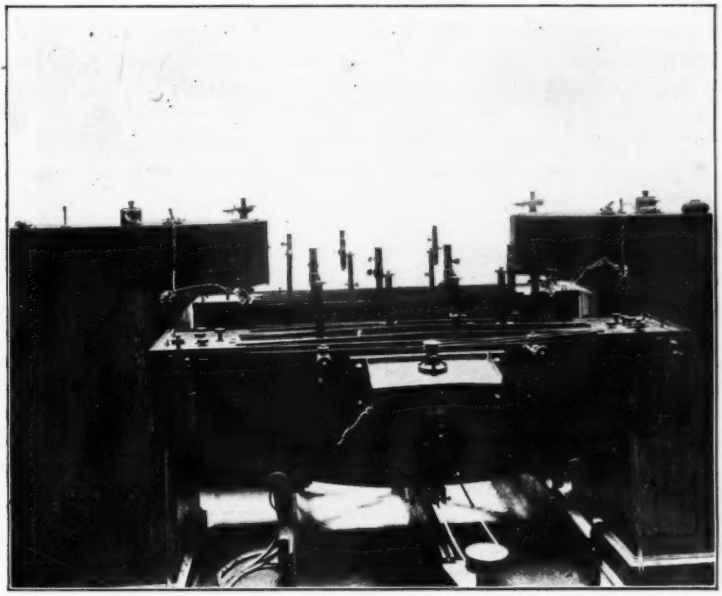
Resistance to rupture....60 to 100 kilogrammes per square millimetre (85,000 to 142,000 pounds per square inch.)

Elongation.....100 to 60 per cent.

A high degree of elongation generally corresponds to a low resistance to rupture, in such a manner that the total work required for the separation of the test specimens is sensibly the same. The above loads for rupture are low in comparison to those for carbon steels, but it must be remembered that the reduced section of the ferro-nickel at the moment of yield is only about one-half that of the original cross-section, so that the actual load per unit of section is doubled, while the remarkable degree of elongation gives a work of rupture higher than that of any metal which has yet been investigated.

Other examples of the tenacity of the alloy are found in the tests at Imphy, where a test bar was elongated 242 per cent. by ten successive tensile loads, the piece being annealed between each load; also, where bars of 10, 12 or more millimetres square were bent close upon themselves without showing the slightest crack.

The industrial characteristics of these alloys, then, are found in their remarkable tenacity, and in the possibility in subjecting them, without



THE COMPARATOR OF THE INTERNATIONAL BUREAU OF WEIGHTS AND MEASURES, PARIS.

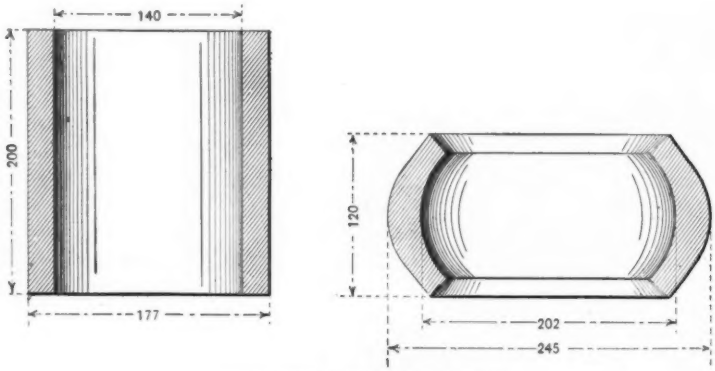
Used by M. Guillaume in his researches upon the expansion of nickel steels.

injury, to deformations under which other steels would certainly show ruptures. When to this is added the fact that they can in no sense be termed soft, having an elastic limit fairly high, often reaching 40 kilogrammes per square millimetre, (57,000 pounds per square inch); that they present no especial difficulties in forging; that, although hard, they are readily worked in the lathe or planing machine, one can form some idea of their industrial future.

I have said of their future, for we are far from having availed ourselves yet of the valuable mechanical properties which these alloys offer to the engineer. From this point of view, the Exposition of 1900 was characteristic; it showed in profusion what might be accomplished with these alloys, but at the same time gave very few examples of what had already been done with them. This task will be that of the approaching years, and the best proof of the important applications which are to be expected is that the greatest establishments, such as Creusot, Chatillon, Commentry, Commentry-Fourchambault, attracted attention by the remarkable exhibits of the prod-

ucts of their forges by specimens showing the texture of the metal and the lines of deformation, or as a more popular illustration, by a serpent as thick as the arm of a child, tied in a complete knot while cold. This and a number of other examples are shown in the illustration. Page 81.

Nevertheless some applications have been practically realised, notably in military work, where the relatively high price of these

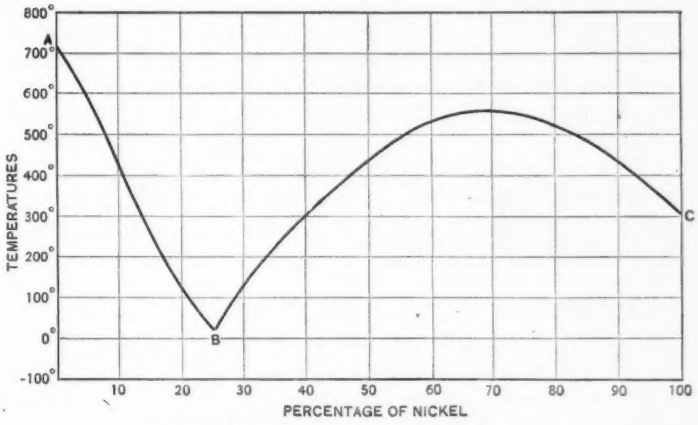


TOUGHNESS TEST OF NICKEL STEEL.

The hoop shown in section on the left was compressed by a load of 900 tons to the shape shown on the right, without showing any cracks.

alloys plays a secondary part. Armour plates, gun shields, and hoops of various kinds to serve as reinforcements to the shocks of projectiles or the bursting of pieces of artillery, have been constructed. An example of such work is seen in a hoop made by M. Jacob Holtzer, which was subjected to the following test. The test piece was a cylinder 200 millimetres in height, 177 mm. in external diameter, with walls 11.5 mm. in thickness, and being subjected to a load of 900 tons (metric) it was reduced to 120 mm. in height. The extension of the interior fibres attained 46 per cent., without the formation of fissures of any sort.

Returning to the scientific study of the alloys, if we increase the content of nickel we do not find more than one of the various characteristic peculiarities at any given temperature; each alloy possesses, on the contrary, at a determinate temperature, certain definite, physical properties. Thus we have alloys which at ordinary temperatures are non-magnetic, but which become magnetic when cooled; but when the original temperature is restored the magnetism disappears. As the



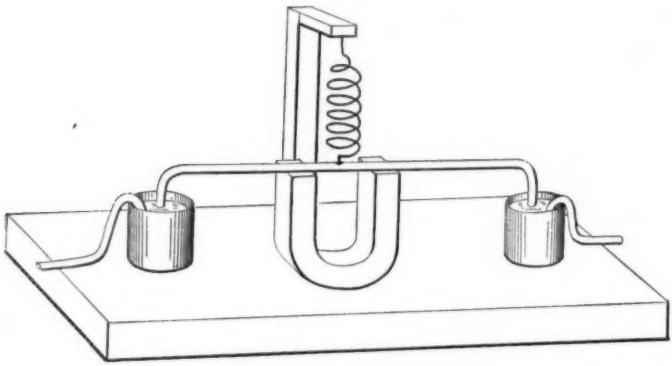
MAGNETIC TRANSFORMATIONS OF NICKEL STEELS.

Showing the temperatures at which they become magnetic upon cooling.

content of nickel is increased the temperature at which the magnetism disappears is elevated, and may attain or pass 400° C. A clear idea of this phenomenon and of those which have already been mentioned, will be obtained from the diagram above.

The curve A B C represents the temperatures at which the alloys become magnetic upon cooling; and we see that while in the portion A B they retain their magnetism in retraversing the curve of heating, they lose it in traversing the portion B C, this part representing the alloys containing from 25 to 100 per cent. of nickel.

This variation in magnetism of nickel-steel alloys of the second category may be utilised in several ways. The loss of magnetism by reheating being gradual, and not abrupt, such alloys may be used as magnetic indicators of temperature changes. I myself have also used them in the construction of an automatic circuit-breaker, operating in a very positive and satisfactory manner and continuing indefinitely operative. The principle of this apparatus is shown in the sketch, page 86. A wire of nickel steel, containing, for example, 30 per cent. of nickel, has its ends bent down into two mercury cups, so as to form a portion of the circuit. It is subjected to the upward force of a spiral spring, and to the downward attraction of a permanent magnet. If now the wire becomes heated by the current above a certain temperature, it loses its magnetism, and the attractive force of the magnet no longer affecting it, it is raised by the spring and the circuit is broken. When



A NICKEL-STEEL CIRCUIT BREAKER.

The nickel-steel wire, when heated by the curent, becomes non-magnetic, and is lifted by the spring, breaking connection with the mercury cups.

the wire is cooled its magnetism returns, and it may be replaced at will. This apparatus possesses several advantages over fusible wires. The connection may be immediately re-established, its action is always the same, and by the selection of a suitable alloy and a spring of proper strength it may be given any desired degree of sensitiveness. For example, I have constructed a circuit-breaker of this type which responded very exactly to a current of 0.4 ampere. The straight wire may, if desired, be replaced by a spiral of fine wire.

The most singular properties, however, of the alloys of this category are those relating to dilatation. No matter how small they may be, the dilatations of metals make themselves felt in a great number of cases. Without mentioning the important subject of measures of precision, it is only necessary to refer to the spaces left between the rails of a track, to provide for the expansion due to warm weather. It is also well-known that all large metallic structures must be provided with means to permit expansion and contraction, due to changes in temperature. An idea of the magnitude and character of expansion may be obtained by the use of a simple apparatus, composed of a cast-iron base, 40 to 50 centimetres long, carrying two posts, one of which serves to hold one end of the bar under investigation, while the other is finished to a smooth plane surface. The only additional apparatus required is a burner, and a sheet-metal shield to protect the bars of metal from the direct action of the flame. As an indicator a pin may be used, this being introduced between the finished surface of the post and the bar under examination, a piece of straw being gummed to the

pin. As the bar expands under the action of applied heat, the pin rolls between the under surface of the bar and the top of the post, and the movement is so magnified by the piece of straw as to be plainly visible. If the expansion of one bar is known, the relative expansion of another may be measured by the relation of the angles described by the two pieces of straw.

Such an apparatus is necessarily very crude. For very exact determinations I have used the comparator by means of which the prototype metric standards were investigated before being sent out to spread the use of the metric system through the civilised world. Page 83.

This apparatus consists of two fine microscopes supported upon stone piers, by means of which very precise measurements of the variations in length of bars placed between them may be made. The bars may be placed in a trough filled with water, this permitting a determinate temperature to be very exactly applied and measured. In an instrument of this sort the errors of measurement never reach the thousandth part of a millimetre, while the precision of the temperature measurements is relatively still closer.

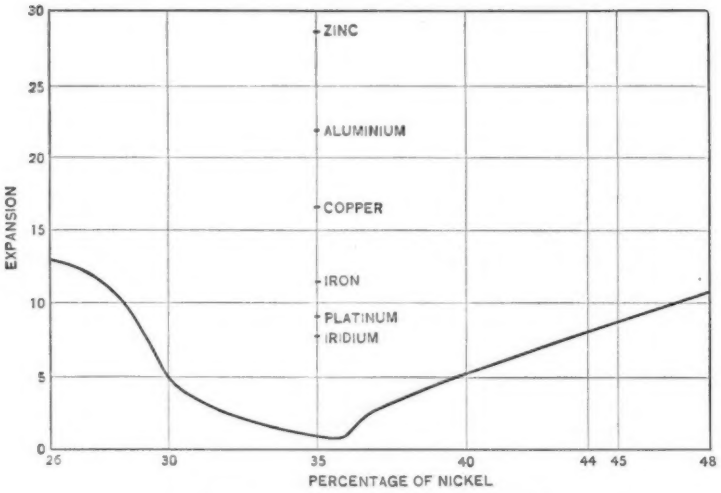
By the use of this instrument it has been possible to determine the expansion of a great number of nickel-steel alloys, and to represent the relative expansions in the form of a curve in which the expansibility is shown as a function of the content of nickel. Page 88.

The other indications on the diagrams give the expansion of various metals, from iridium, the least expansible, to zinc, the most expansible of the industrial metals.

We see here the singular fact that there exists among the alloys of iron and nickel one which has but one-tenth the expansibility of platinum, and one-thirteenth or one-fourteenth the mean expansibility of iron or of nickel.

This fact is proven beyond doubt; it will probably take years of study and investigation to discover an explanation of the observed facts, and physicists of the present day are by no means in accord concerning the theory involved. I shall therefore make no attempt to discuss this side of the question at this time, but rather consider the practical applications which may be made of these singular facts.

If nickel should ever reach the price of iron, which can hardly be hoped, the nickel-steels of minimum expansibility would immediately assume a colossal importance. Since these alloys are at the same time very tenacious, relatively soft and easily worked, and so little



EXPANSION COEFFICIENTS OF NICKEL STEELS.

The ordinates give the coefficients of expansion for 1° C. to the sixth decimal place. Note the very low expansibility of the 36 per cent. alloy.

oxidisable that they may remain immersed in water for weeks without showing anything but minute specks of rust, it is evident that they possess all the advantages of ordinary steel for structural purposes, together with other most desirable properties.

But without dreaming of the future, and limiting the applications of these alloys to their immediate conditions, we have special uses in horology, and in measurements of precision. In horology the application has already been made, since a large number of makers in various parts of Europe have abandoned the old-fashioned gridiron or mercury compensating pendulum, in favour of a simple rod of nickel steel, carrying a bob of brass or iron, the expansion of the bob alone being amply sufficient to compensate for the very slight expansion of the rod. Pendulums of this construction are in use to-day in a number of observatories, with excellent results.

In geodesy also there has been no delay in the use of the new alloys. In all geodetic measurements made at the present time a very high degree of precision is demanded, and it has been found very difficult to obtain satisfactory temperature conditions.. Two systems have been employed in the measurement of geodetic base lines. The first, which is very precise, consists in carrying over the line a heavy

standard bar, four or five metres in length, together with a mass of *matériel,* including trestles, microscopes, telescopes, etc., in a word, in traversing the line with a portable observatory. In the United States, this has even been carried so far as to provide for the surrounding of the bar with a jacket of ice, in order to maintain an invariable temperature. By the use of the new alloy all these precautions become unnecessary, without affecting the accuracy of the work.

The second method of measuring base lines is much more rapid; it consists in the use of measuring wires, 20 or 24 metres in length, subjected to uniform spring tension, and stretched from trestles placed on the line of the base. In this method the determination of temperature is much more defective, and appreciable errors occur. By the use of wires made from the non-expansible alloy, however, this rapid method is given a degree of precision to which it could otherwise have made no pretensions. Experience has shown that the nickel-steel wire method of measurement bears out the theoretical predictions. In the important expedition of Russian and Swedish savants to Spitzbergen, all the bases were measured with nickel-steel wires, and the precision attained exceeded all expectations.

When a non-expansible metal is spoken of, it at once suggests applications to scientific instruments and apparatus, in which such a material immediately removes all the errors which for more than a century have been combatted by the use of complicated and difficult constructions. Even if it is not yet possible to realise the advantages of a non-expansible alloy in large metallic structures, such a material need not be considered as banished from all practical work. I have already spoken of its use in connection with the construction of astronomical clocks, and it is applicable to ordinary clocks as well. By means of the use of this alloy in the construction of the balance wheel for the marine chronometer, practically all the errors due to changes of temperature are eliminated, thus affording the most simple solution possible of a problem which has occupied the attention of the most eminent horologists for centuries.

Again it is impossible to compute the number of accidents which have occurred by the rupture of steam-boiler tubes, due to the difference in expansion between the tubes and the shell to which they are secured. Many lives have been lost and much suffering caused by the ruptures which have been caused by this action, permitting torrents of scalding water to be poured upon the attendants.

Already Mr. Yarrow, the well-known constructor of marine water-tube boilers, has called attention to the importance of nickel-steel

tubes because of their resistance to corrosion. Nevertheless Mr. Yarrow has considered but one side of the question, and in relieving the liability to rust he has produced unfavourable conditions by using a nickel-steel alloy which has a high expansibility. By selecting the proper alloy it is possible to remove nearly all liability to corrosion and at the same time to avoid the strains due to unequal expansion and contraction, thus greatly diminishing liability to accidents.

In this rapid review of the properties and applications of nickel steels it has been possible to glance only at the many points which might attract attention. To what are these singular properties due, unknown as they are to any other combinations of metals? How can we explain these multiplex transformations? These are questions of the highest importance in the study of alloys in general, and of steels in particular. The problem is but partially solved at the present time, and yet it already begins to throw light upon the general subject of the nature of steel.

As for the industrial applications, without attempting to enumerate or predict all, one may at least affirm that nickel steels of various composition will become more and more used in all cases in which, by a greater or less increase in the price of the product, one may make use of a metal of the highest degree of security, of the least susceptibility to corrosion, and of the maximum durability. When, in addition to these conditions, the properties of magnetism or of expansion and contraction enter into question, nickel steel will meet the utmost demands of the engineer.

THE WORKING ECONOMY OF THE STEAM BOILER.

By Charles Arthur Hague.

Misunderstandings cause more trouble than misintentions, and anyone who aids in bringing the two parties to a contract nearer to a point of mutual comprehension renders a service. Their bargain stands firm and satisfactory to each, because both agree as to what each had agreed to. It is in this spirit that Mr. Hague discusses the purchase of a steam-boiler installation. He does not at all criticise the "expert test" *per se*, but merely points out that the results of such a test are generally to be regarded as a standard of comparison, not necessarily a standard of daily performance. To make the comparative performance standard, conditions must be brought as near absolute perfection as possible to eliminate all uncertain factors; and this is the avowed purpose of the expert test. Such conditions may not be economical in regular working, but the records obtained under them afford a basis for judging the work of the plant from day to day, and also for comparing it with other installations. So understood by both sides, it becomes a datum of value to the owners and can no longer be a cause of disappointment or contention.—THE EDITORS.

VEN though the number of different kinds of steam boilers does not amount exactly to legion, there are nevertheless very many of them, and the characteristics of economy, safety, danger, high and low cost, and other features, go to make up a subject of great interest to the designers, buyers, and users of steam generators. There are horizontal return-tubular boilers, locomotive boilers, water-tube boilers, plain cylinder boilers, vertical tubular boilers, and various patented but indescribable boilers of all kinds and patterns, all of which have their advocates more or less sincere and more or less interested in the commercial success of particular types, as well, of course, as the advantages to the buyers.

The proposition seems simple enough to provide a steam boiler for any particular use—a water-tight and steam-tight vessel, arranged so that it may be subjected to the heat of the combustion of some kind of fuel and so generate steam. But with all its seeming simplicity, there is plenty of room and opportunity to go wrong with the proposition and get into all sorts of disputes as to the various results really obtained, kinds and mixtures of coal, manner of firing, and general manipulation or special management of the boiler, steam, or fuel. Sometimes when one boiler is bought and installed there seem to be in

reality three of them; one boiler the way the boiler-maker thinks it is, one boiler the way the buyer thinks it is, and one boiler the way it really is. What we want to know in any certain case is that form, proportion, etc., of boiler which will give the best efficiency and economy as a steam producer, secure the best conditions for operation with the given sort of fuel, the expected manner of firing, and the customary working conditions of the plant generally.

In determining upon the type, size, capacity and other items, it will be seen at once that two distinct lines of consideration are open, and experience proves that misunderstandings and differences of a serious nature, sometimes amounting to law suits, not infrequently follow uncertainty as to which line is to be followed. These two lines are indicated by the boiler-maker's point of view, and the buyer's or user's point of view. The boiler maker follows certain lines, sometimes comparatively arbitrary, basing his conclusions upon what he has been in the habit of doing in his boiler business and wants to continue doing in the future. The buyer is principally interested in knowing how much steam he can make, and how inexpensively his steam can be produced by the use of the coal he can buy in the market to the best advantage at his particular location. A failure to state in a boiler contract which line is to be followed, or a refusal to follow the line so selected, by either party thereto, will generally be productive of disagreeable consequences.

The boiler maker wants his boiler tested by some particular or standard kind of coal, regardless of its price and of whether the user wants to buy such coal or not. He wants this particular kind of coal manipulated and handled by the most skilful expert fireman he can scare up and put at the task, regardless of this expert fireman's pay, even though it may be double what real economy of regular operation could expect or enjoy; the expert fireman's sole aim being, for a very brief period of time, to secure the highest and best rate of combustion of the selected fuel. For this test the boiler maker wants his boiler cleaned and scraped inside and out, sometimes even claiming the privilege of stopping at any time he thinks cleaning ought to be done during the test. He wants his boiler operated at a rate best suited for making the best showing, regardless of regular working in everyday performance. In addition to all this, there are certain preparatory runs and some preliminary groomings desirable—then a certain manipulation and stage of the fire at the commencement of the trial run or test—then the special operation of the boiler by the skilled attendant during a specified time, usually twenty-four hours. Finally, at the close, the fire again

carefully manipulated and brought as closely as possible to the condition observed at the start.

The buyer's "test" is very different and very simple, consisting in working the boiler in the manner ordinarily followed in everyday operation, by the regular attendants, with the coal burned and the steam made carefully noted; this regular running of the plant including the usual methods of firing.

Of course, a steam user ought to know and insist upon the best average work to be obtained for fair wages, and the most economical coal, all things considered, to be had in his locality. There are no objections to testing a boiler under expert conditions, especially if the test is standardized, as it will then be placed upon a basis for comparison with the work of other plants and a valuable insight will be obtained by the user as to what his boiler ought to be doing. The main trouble to be avoided is the installation of a boiler capable of generating the required weight of steam per hour *only* under expert conditions, and not able to do the required amount of work under the everyday conditions; close competition under too open specifications will sometimes lead to such mistakes, and, with adequate "jockeying," the boiler will appear to come up to the economy and capacity specified in the contract; but when the buyer protests and talks about rejection, his legal adviser will perceive and tell him that the contract he has signed does not deny to the boiler maker the right to do as he has done in making his test.

But the steam user can not hope ever to reach expert results in regular work. All he needs to know or to do, in buying his boiler, is to understand clearly from which point of view he is looking at the contract before he signs that instrument, and then he will be saved the mortification of having the boiler maker ring in an expert test upon him and obtain results thereby which ought to be at least approached under ordinary conditions. If he does buy boilers to be tested under expert conditions, he has only to insist that they shall make as good a showing as other boilers of the same type and size under like conditions; then he may rest assured that he must obtain the highest practicable percentage of the expert results in everyday work. The main thing, after all, to look out for, is that we generate at least the actual amount of steam needed, under ordinary conditions of service; for without this, the excess shown by the expert test will avail nothing. And this suggests an axiom recently coined by the writer:—

"An excess of steam made one hour is of no use during an hour when the supply is short."

Steam is elastic, but not to such an extent as this; boilers are sometimes made so closely for their work that during an expert test the fire and feed water can be manipulated so that a fat fire one hour may be burned down to a thin fire another hour, and, although the average of the run may show full capacity of steaming, many of the separate hours can be picked out during which a serious percentage of shortage occurred. A boiler should not be figured so closely that its so-called excess capacity must be called upon for regular service.

When it is known that the enormous sum of nearly $600,000,000 is annually expended for steam coal, in the United States, it is not difficult to comprehend the importance of proper and efficient methods in the construction and operation of boilers. And if these figures are not sufficiently respectable, it may be considered that at an average evaporation of eight to one, the weight of water annually turned into steam amounts to more than 3,200,000,000,000 pounds, or 1,600,000,000 tons. But these figures relating to distinct elements, as they clearly do, suggest at once that the generation of steam, or, in other words, the useful operation of steam boilers, should be considered under two heads largely independent of each other in character, but at the same time co-relative in the sense of working together towards a common end. These two heads are:— the proper combustion of the fuel in the boiler furnace; and the absorption of the resultant heat to the greatest possible extent by the heating surfaces of the boiler. They are entirely different in principle, because combustion differs from absorption; but nevertheless co-relative and inter-dependent in a boiler because the action and rapidity of absorption influences and modifies the rate and manner of combustion, while the degree of intensity in the combustion directly affects the absorption of heat.

A brief tangible statement with definite amounts would be say, 14,500 heat units developed by the combustion of one pound of coal; and the absorption by the water in the boiler through the medium of the heating surface of say, 80 per cent. of the heat developed in the furnace—or, say that the boiler gives to the water 11,600 units of heat for each pound of coal burned, the rest of the heat (20 per cent., or 2,900 units) being lost or used up in the preliminary operations of combustion, maintaining necessary chimney temperatures, radiation, etc.

Such very high furnace and boiler-surface efficiency would result in the evaporation of 12 pounds of water from and at 212 degrees F. per pound of coal consumed. Or, with the water entering the boiler at a temperature of 180 degrees, the steam generated per pound of coal

under various pressures would be about as shown in the following short table:—

100	pounds	gauge	pressure	.....	11.19	pounds	evaporation.
125	"	"	"	.....	11.14	"	"
150	"	"	"	.....	11.10	"	"
175	"	"	"	.....	11.00	"	"

Of course, these results are not met with in actual average work, and for the simple reason that the conditions are not, or can not, be easily maintained for their assurance. Expert conditions do not pay for regular duty for the further reason that the coal saved is worth less than the cost of the ultra-efficient service, and that mighty power which we recognize under the name of "the fitness of things" has boiled ordinary service down to what it is, the instincts of the business manager erring more or less in drawing the line, but upon the whole doing very well for a business man.

With the ordinary run of fuel, under ordinary manipulation, probably a development of 11,500 heat units per pound of coal would be fair. And with boilers in the ordinary conditions of cleanliness an absorbing efficiency of 70 per cent. might be considered good; and such a change in the factors of usefulness makes a great change in the results as will be observed in the following:—

Heat units developed per pound of coal.....	11,500	
Heat units absorbed and transmitted by boiler....	8,050	
Evaporation from and at 212 degrees.....	8.33	pounds.
100 lbs. gauge pressure, feed at 180°, evaporation	7.76	"
125 " " " " " "	7.73	"
150 " " " " " "	7.71	"
175 " " " " " "	7.67	"

And so it will be seen that the boiler maker, although he can not control the quality of coal and labor destined to be used with a boiler, can at least, by a knowledge of the possible accomplishments under a certain set of conditions, so proportion and construct his boiler as to produce reasonable results. And it is the meeting of the conditions in any certain case, or the failure to meet them, which results in satisfaction or dissatisfaction to the buyer and user. If a manufacturer or a user of steam power is surrounded by a certain set of conditions, it is of no earthly use to him to be furnished with a boiler which shall be highly competent to meet conditions existing a thousand miles away and entirely different from his own. There has been many a quarrel brought about by these very means; sometimes it is sharp practice, and sometimes only a blunder of the boiler maker's, but the buyer in the

end generally has to live with the trouble all the same. Professional and disinterested engineering advice may seem expensive to a would-be buyer, before a contract is entered into, but the cost of such advice is a good deal less than loss of time, lack in power, or a law suit; perhaps all three may come on at once.

A steam boiler, then, embraces two separate items; the furnace, comprising the grates and a proper combustion capacity capable of generating the utmost amount of heat from the combustible matter of the fuel; and the steam-tight vessel properly arranged and proportioned for the transmission of the greatest possible percentage of the heat generated to the water within the boiler. And before going further it may be well to state in general terms the lines it is desirable to follow in producing a first-class steam boiler.

A. The choice of the best of materials for the various details of the boiler, and practicable means of ensuring the use of such quality of materials by the boiler maker.

B. The greatest possible simplicity in design and construction, ensuring thereby the ready access to all parts for cleaning and renewals, with the maximum of durability and the minimum of repairs.

C. The most skilful workmanship, including efficient means for manipulating the materials so as to prevent abuse and damage to the stock that may be used, including the drilling of rivet holes instead of punching them, also the planing of the edges of plates, proper form of caulking tools, etc.

D. Steam and water capacity sufficient for the preservation of the water level and the steam pressure within close limits, in conjunction with ample water surface for the disengagement of the steam.

E. The greatest possible circulation of the water with the view of its reaching the different parts of the boiler with sufficient thoroughness to ensure the same temperature of the various parts.

F. When made necessary by the quality of the water, which is with few exceptions, a proper mud-drum for the deposit, at a point removed from the effects of the fire, of all foreign matters likely to form scale upon the heating surfaces. A mud-drum can scarcely be said to be a detriment to any boiler, but there may be situations where it might be omitted.

G. Ample and free passageways from and to the different parts of the boiler, so as to preserve equable conditions of the water and steam pressure and to prevent foaming and priming.

H. Avoidance to the utmost possible extent of the exposure of joints to the direct action of the fire, with special reference to rivets, two or more thicknesses of plates, etc.

I. A large factor of safety as regards strength, over and above the highest possible strains and working pressures; with special care in endeavoring to avoid the deadly enemy of the steam boiler, unequal expansion.

J. Particular attention given to grate areas, combustion chambers, etc., with reference to various kinds of fuel, especially as to hard coal, soft coal, and the different qualities of these separate kinds.

K. The disposal and arrangement of the heating surfaces so as to secure the greatest possible transmission of heat from the products of combustion to the water, always remembering that the heat is the element which does the work, the water acting only as the vehicle for transporting the heat from the combustion to the point of usefulness; also remembering that the greater the percentage of the heat of combustion taken up by the boiler and transferred to the water, the greater the economy.

L. When operating at the full steaming capacity for which it is designed, the utmost fuel economy should be attained by the boiler without undue forcing, or deficiency in the quality of the steam.

In considering the different attributes of the steam boiler, there is no room for argument regarding the importance of the factor of safety. Safety is paramount to all other considerations, and the idea of the necessity of safety is as absolutely instinctive as is the first law of nature, self-preservation.

The wonder is that more explosions do not take place, when all chances are weighed and one stops to think of the enormous aggregate load and capacity for work stored within a boiler. But even as it is, there has been, making an average for the past eleven years, a boiler explosion every two days, involving the death and serious injury of an average of two persons for each day throughout the eleven years.

The reports of the Hartford Steam-Boiler Inspection and Insurance company indicate that out of about a million of boilers met with in their business, more than 11 per cent. were in a dangerous condition. And boilers have exploded very soon after inspection and insurance, or renewal of insurance; and why? For the simple but adequate reason that it is possible to have cracked plates which can not apparently be discovered or known until after an explosion has laid the peril bare. The overlapping seam so commonly used in boiler construction

for longitudinal joints is a very treacherous affair at times, and cracks from unequal expansion and other causes may develop unseen in the plates at such seams, gradually growing worse even to the point of destruction, unless a tell-tale leakage of water shall give friendly warning of danger. The butted joint with a welt inside and out is much safer, and really the only proper joint for such a place. Who knows how many lapped seams have a cracked plate gradually approaching the danger line? Of course the actual cause of explosion is, that at some critical moment unforetold and unannounced, when a variety of dangerous factors happen to act together, the strength of the boiler or some part thereof is less than the strain or strains imposed. And as those arch-fiends, unequal expansion and corrosion, begin their work from the moment the boiler is put into service, they will wherever they occur eventually weaken the boiler to a more or less dangerous extent, their special product being fractured plates near or at the seams, and through the lines of rivets.

The desirability of good circulation of water has been already pointed out, and it is no doubt the lack of proper circulation which causes most of the unequal expansion, this varying strain, sometimes enormous, being oftenest caused at the time the boiler is undergoing the process of getting up steam, which would account for the cases wherein boilers have been running along in apparent safety, the pressure has been taken off, the boilers carefully inspected and then fired up again, but explode long before the regular working pressure has been reached, or soon after attaining a pressure no greater than that which they had been under for a long time. Whatever the type of the boiler, one aim should always be kept in view—to provide against straining the material during the cooling off or the heating up so often necessary in practical operation. And in providing against this strain, very much may be accomplished by the manner of arranging the parts of the boiler with relation to one another, so as to take every possible advantage of the elastic qualities of the metal in yielding to distortion of forms to a certain extent, instead of taxing perhaps to the utmost limits the elastic bounds of the material itself by direct strains among its atoms.

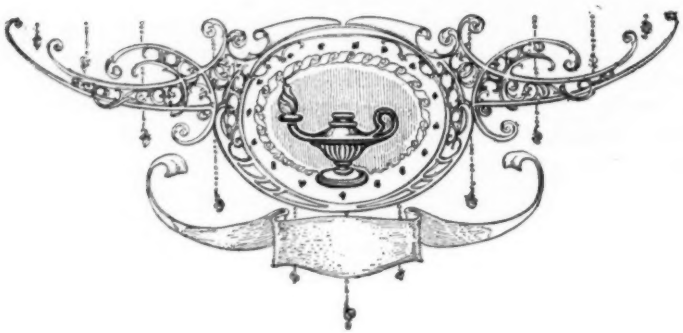
This matter of circulation is so important both for economy of heat utilization and for reasons of safety and durability, that it will be well to look a little further into its character. The value and nature of this operation which goes on within a steam boiler may be readily observed, by means of a glass vessel filled with water in which the fluid is caused to boil by applying an alcohol lamp beneath the vessel. The heat from

the flame of the lamp striking and spreading under the bottom of the vessel and extending a little way up the sides, especially if the bottom is somewhat rounded, is conducted through the substance of the glass and absorbed by the water in contact therewith. Now, water being a non-conductor of heat to a remarkable degree, in fact almost a perfect non-conductor, although a quick and rapid absorber of heat, but at the same time possessing the quality of expansion when heated, we may observe a very important effect with respect to its action within a boiler. The conduction of heat between the particles of water being so slow as to be practically none at all, but the water in contact with the heated glass absorbing sufficient heat to produce expansion, and reduction of weight per unit of volume, the particles of water thus lightened immediately take to themselves the qualities of flotation with reference to the colder particles, and start upwards for the surface of the body of water. Following the line of least resistance, the heated particles of water keep next to the sides of the vessel, and when they reach the top the action which we recognize as "boiling" of the fluid takes place; the surface being raised and disturbed at the sides, and depressed at or towards the middle of the glass, the latter effect being aided by the downward rush of the cooler water to take the place of that which has been heated and caused to rise. This action starts and maintains the motion of currents in the water which is denominated "circulation," and when this important operation is carried on under a temperature and pressure corresponding to each other steam will be given off at the surface of the water. Circulation of the water in a boiler then, is the act of absorbing heat by the fluid at its places of contact with the heating surface, the rush of the steam and hot water to the liberating surface, and the flow of the cooler water into contact with the heating surface. The facility, ease, promptness, and uniformity with which this action is accomplished in greater or less degrees mark the various qualities of safety, durability, and economy of different designs of steam boilers. Safety, because the uniform heating of the boiler's parts prevents unequal expansion; durability, because the absence of dangerous strains and conditions conduces to longevity; economy, because the complete and rapid heating of the water results in the absorption of the heat generated in the furnace, to the greatest possible percentage.

But the statement of the case as set forth in the heating of the water in the plain glass vessel, as already described, indicates a capacity for heating water which is limited when the line is reached at which the upward-rushing steam interferes with the downward-flowing water.

And the only way so far in the art of boiler making to accomplish anything better and greater than this, is to separate by arbitrary methods the two opposing currents—that is, so to construct the boiler that certain parts are naturally convenient and easy for the escaping steam to go to the liberating surface of the water, and also so that the water which must be turned into steam may easily and naturally go to the heating surface; and as the steam and water under any pressure are at the same temperature, it follows that a rapid and thorough circulation will produce uniform results in heating the various parts of the boiler, it being borne in mind that the most perfect circulation does not take place while steaming because one part of the water is particularly hotter than another part, but because the heated water and steam next the active heating surface is lighter per unit of volume and consequently endeavors to rise to the surface, this effect being assisted by the efforts of the steam to expand in the direction of the outflow, which of course means the steam space of the boiler and thence the steam pipe.

In short terms, when the boiler is such that the upward and downward currents, so to speak, interfere with each other, the boiler will produce over-saturated steam, will foam or prime, and will be wasteful of fuel. But when the boiler is such that the upward and downward currents are separated and arbitrarily kept apart so that each may follow its own course uninterrupted, then more steam may be made, there will be no priming or foaming, and the fuel will be economized.



EDITORIAL COMMENT

IN recent years there have been many instances of likeness in the experiences of the two great English-speaking nations, both in home and foreign affairs, and it cannot be doubted that this parallellism has tended to aid the multiplying material ties in drawing British and American sympathies closer together. And now, within a few months of the death of the Queen, the United States have been brought suddenly face-to-face with the situations attending the sudden removal of the head of the political system. After a week of tense anxiety, hope once rising so high that it almost dispelled fear, President McKinley died while his country was yet vibrant with echoes of his last great speech —a speech deeply significant of the broadening of commercial horizons which has come to the United States and to American statesmen since the first inauguration of the late President.

As in the case of the demise of the Crown, the event has been striking in its exhibition of the soundness which has come into the organisation of the modern State since political considerations pure and simple, as they were once understood, (but they were neither "pure" nor "simple") have been deposed from first place and made wholly subordinate to industrial considerations. The rapid and enormous spread of means of communication, whether of persons, goods, or intelligence, has drawn the whole world together to the point where mutual support becomes stronger than mutual rivalry. The upbuilding of sound commercial and financial enterprise, the co-operation in the development and use of natural resources, have created a structure which is itself in the truest sense the State. The State is no longer a mere political ideal, nor only a sentiment of loyalty to a certain dynasty or individual government. It is an embodiment of the material resources of the nation, a centred expression of the forces of production and distribution, to which the executive, administrative, legislative and military are servants and instruments, and to which therefore the passing of even the most exalted and esteemed ruler brings but a passing tremor. The disturbance is somewhat greater in the United States than in Britain because in America economics and party platforms are more closely—too closely—intertwined. But in New York, as in London, an event which not many decades ago might have shaken a continent and upset the peace of nations, does not markedly arrest the course of business nor seriously shake financial security. And this work of industrial development, of trade extension, of spreading and constantly bettering the lines and lanes of communication, is primarily and essentially the work of the engineer.

* * *

AT the time of the completion of the tenth year of the publication of THE ENGINEERING MAGAZINE, the announcement was made in the April issue of the current year of the forthcoming publicatien of the Third Volume of the Engineering Index. The magnitude of this undertaking has been such as to preclude its completion until the present date, although it has occupied the time of a special and active staff, but we now announce the completion of this great work, and its appearance during the current month.

The extent to which the engineer of to-day is dependent upon current technical literature is hardly appreciated, even by those most conversant with the subject. Any attempt to gather information from text books and works of authority must

be accompanied by searches through files of scientific and technical journals if the present state of an art is to be learned, and the amount of labour which such researches involve is not only enormous, but has to be frequently repeated, when it is undertaken independently. With the present volume and its two predecessors, however, the field of technical periodical literature is indexed from 1884 to the close of 1900, in such a manner as to justify us in saying that the work has been done once for all, and he who undertakes a search for any subject of even minor importance on his own account, instead of consulting the Engineering Index, is merely repeating what has already been done for him more fully than he can hope to accomplish by his unaided efforts.

The Third Volume of the Engineering Index is now offered as a fitting memorial of the work of THE ENGINEERING MAGAZINE in its special field, a record of the work of engineers all over the world in the closing five years of the nineteenth century.

* * *

THE present interest in dirigible balloons, largely excited by the experiments of Zeppelin and Santos-Dumont, has revived the question of the possibility of ever achieving any permanent and practical success along such lines. It has long ago been admitted that the success of a balloon which should be dirigible in calm weather or against light winds, was dependent entirely upon the production of a motor which should be sufficiently light and powerful to operate propellers of large enough capacity to move the balloon by which they could be carried. The experiments of Krebs, Renard, and others, as well as numerous model trials, have demonstrated this.

The development of the internal-combustion motor for automobile vehicles has furnished a motor so much lighter than anything possessed by these earlier experimenters, that a measure of success has been attained in the air generally comparable to that secured on land. At the same time it must be remembered that the motor is but one factor in the problem, and that a point must be reached in every case where the force of the wind acting against the body of the balloon must be greater than that of any propeller which it can sustain; and just as there is a limit to the current which can be stemmed by a steamboat, so there must be a limit to the wind against which the most powerfully propelled balloon can be navigated. The dirigible balloon can, at best, be but a special apparatus, possibly useful in some instances in warfare, more probably as an object of interest and amusement at expositions, and very remotely as a means of actual useful travel. The air-ship of the future is far more likely to be a veritable flying machine of the aeroplane type, and in spite of recent developments, it is to the work of Langley and not to that of Santos-Dumont that we must look.

* * *

IN view of the recent discussion at the meeting of the Institution of Naval Architects, concerning the desirability of constructing a testing tank to be at the disposal of private ship-builders for experiments upon hull models, it is interesting to observe that at Washington is the only government tank which is open to the service of the public. The tank at Haslar is available for government work alone, and is fully occupied at that, even if the disposition to place it at the service of private builders existed. Messrs. Denny naturally reserve their private tank solely for their own work, and state that they could keep a second one busy if they had it. The new tank of the North German Lloyds is also private, but the remarkably fine tank at the Washington Navy Yard, while primarily built for the government service, has been available for public service from the first. In addition to this, the remarkably ingenious machinery for the construction of models which shall be accurately reduced copies of the actual hulls, enables all model construction to be omitted by ship-builders, it being only necessary for the drawings to be sent, and the model 20 feet long is made and the auto-

graphic records at the desired speeds furnished, at a charge barely sufficient to cover the cost.

In view of the valuable results which have been achieved in the past by the study of the resistance of models, both as to improvement of lines and correct powering of the completed vessel, the importance which was laid upon the testing tank at the meeting of the Institution of Naval Architects is apparent, and it is to be hoped that the efforts of the Institution to establish a public tank will be realised at an early date.

* * *

THE history of the international yacht races covers the entire period of the change from wood to iron, and still later steel or bronze, as the principal material of naval architecture, and it would be strange had there not been a very great accompanying change in the characteristics of the contestants for "The Cup." Probably, however, the most marked changes have occurred during the last twenty or twenty-five years. At the beginning of that period the contest was clearly and uncompromisingly declared between the deep cutter and the shallow centerboard boat, the "skimming dish," as it was contemptuously called, and England and America went to extremes in their devotion to the development of these two types. By a series of mutual approaches, in which it would seem the United States have conceded far the most in principle, the lines of the two models have been brought toward a common type. The bodies of the two yachts are so alike that the layman sees only what seem to him minor differences of modelling; and it is upon these refinements of line and of structure—not on any radical changes—that both British and American designers have been spending their study and labour for some years past. The differences between Shamrock I, Shamrock II, the Columbia, and the Constitution, are so small relatively as to suggest that the designer has nearly reached his limit. It is the metallurgical engineer who has aided him in going so far—possibly in some yet undeclared discovery of the furnace or the rolling mill will lie the possibility of a new line of advance.

* * *

THE strike of the Amalgamated Association in the mills of the United States Steel Corporation, after dragging its slow length along through another month, has reached a settlement which leaves the conditions at some points more unsettled than ever, though the indications point to an early ending of the whole performance. From the labour-leaders' point of view it can hardly appear to have been a highly successful production, and from no point of view does it appear a strongly spectacular one; but probably it has done more to advance the cause of wise and well-ordered unionism than any labour struggle since the great engineers' strike of 1897. Where construction has been so badly designed as that of most of the trade-union "organisers," the first step toward real advance is to pull down what has been done and begin afresh, and Mr. Shaffer has apparently pulled down most of his particular union about his ears. The part which will stand, and by its soundness furnish the plan and pattern by which to rebuild, is that which he could not move when he tried to drag the Amalgamated structure onto the bad ground he had chosen.

* * *

THE lessons of value which have been taught by the strike—which, if accepted and acted upon will form the basal principles of a trades-unionism as helpful to employers as to workmen—are that the labour-organisation, like any other institution, if it is to succeed must be reasonable, just, and responsible. The old adage puts it more tersely—"Honesty is the best policy." And when the unions regard themselves, or are compelled by the courts to hold themselves, responsible for their agreements and their actions, this one new condition will quickly bring to their leadership men of sufficient calibre to direct them with justice and reason. It was largely because of the one feature of irresponsibility that the older unions

pushed into prominence the leaders of theatric but reckless type who caused the deplorable and riotous strikes of recent memory. When a vote carried no responsibility, it was lightly cast for the labour demagogue of smooth tongue, fair promises, and light allegiance to ideas of right or order. But when the workingman realises that his ballot involves his material interests in exactly the same sense and proportion as does that of the shareholder in a corporation, he will be more discriminating. The certain result will be the appearance of a class of labour leaders governed by a sense of accountability, akin to that which rules the officers of a business corporation, and with them sound business methods and ideas will begin to dominate the workmen's aims and efforts. For the unions, even more than stock corporations, in kind and in the average are what their officers are. There may be, among the many stockholders of the United States Steel Corporation, men who would have handled its affairs with the weakness, the buncombe, the arbitrary unreason and irresponsibility characterising the attitude and course of the Amalgamated. There may be men in the ranks of the workmen—and the straightforward conduct of some of the lodge shows the type is there—who would have handled matters with the strength, patience, and fairness displayed by the board of the United States Steel Corporation. But the shareholders of the corporation had to assume financial responsibility for the mistakes and all the conduct of their officers; the steel workers ostensibly did not. The one set of conditions brought to the front Mr. Schwab; the other produced the leadership of Shaffer. Recent notes in the press indicate that the British trade unions, alarmed at the decision of the House of Lords referred to in our last issue, are seeking to minimise their tangible responsibility. Their way to success and prosperity, as well as to sound usefulness, lies in frankly and fully accepting it. They cannot force "recognition," but they can win recognition by showing themselves responsible.

So much has been said and written about the "American invasion of Europe" that one introduces the subject with an apologetic air and in an attitude of readiness to dodge should some overtired patience heave a brick at him. The seemingly paradoxical excuse for saying anything more is that there is very apparent danger of saying too much—at least, danger to the American. There is danger to him, first, of being lulled into that very over-confidence of which he accuses Britain, and which gave him his recent great opportunity. There is danger, next, of overlooking in his enthusiasm the apparent fact that he has been to a considerable extent "filling up a hole" in Europe's needs of mechanical and engineering products, and that it looks a good deal as if the hole were getting filled.

By no means would we imply that American exports are going to cease—far the contrary—but merely that the *rate* of the past four years should not be counted on for the future. Britain and the Continent have been "catching up," and the American manufacturer will find his European competitors meeting him with his own ideas, improved where possible.

Export business will be immensely and increasingly valuable to the far-sighted American—an outlet for his full product, a balance against home depression; but it will hardly grow of itself as rapidly as it has done. It will need more cultivation, more active canvassing. He will have to seek it as he does his home business—as the British manufacturer has long sought business abroad.

* * *

THROUGH the negligence—or more probably, it is to be feared—the malicious misconduct of a messenger, the manuscript of the second portion of Herr Lüders' review of "American Machine-Shop Practice from a German View-Point" was lost on its way to the composing room. We yet hope to duplicate it from Herr Lüders' notes; but there is not time before we must go to press to receive his reply from Berlin and get his article into type. The paper must therefore go over until November.

REVIEW OF THE BRITISH PRESS

Recent Marine Engineering.

AMONG the important papers presented at the recent meeting of the Institution of Mechanical Engineers at Barrow-in-Furness may be mentioned the review of marine engineering, by Mr. James McKechnie. For the three past decades papers have been presented reviewing the progress of the preceding ten years in marine engineering, this making the fourth in a notable series dealing with the greatest engineering industry of Great Britain.

Mr. McKechnie starts out with the proposition that progress must primarily be measured from the standpoint of economy, the success being determined according to the relation between the work accomplished in carrying a given load a determinate distance, and the expense involved in doing it. In determining the progress made, Mr. McKechnie takes his data from actual performances at sea, rightly considering these to be better measures of true progress than results obtained from trial trips.

Considering the advance in fuel economy, it must be remembered that the advance must be a progressively diminishing one. In 1872 the coal consumption was recorded as 2.11 pounds per unit of power per hour; by 1881 it had been brought down to 183 pounds; in 1891, when the triple expansion engine had come into almost universal use, the rate became 1.52 pounds; while a careful analysis of new ships with the latest equipment is about 1.48 pounds.

"The increased economy is partly due to the higher steam pressures now in use. In 1891 the average was about double that of 1881, and now the increase is from 158 lb. to 197 lb. per square inch, the average for forty-five ships with triple-expansion engines built within the past nine months being 180 lb., and for nine steamers with quadruple-expansion engines 214 lb. In former years naval machinery was included in the reckoning, the conditions being similar to those obtaining in the merchant service; but now, with the adoption of water-tube boilers, the practice is dissimilar, and naval ships are not considered in determining this year's averages. As a result of the higher steam pressure and more economical engines, more power is obtained from the boilers per square foot of heating surface, the average per indicated horse-power having in ten years decreased from 3.275 to 3 square feet. At the same time the piston speeds of engines have considerably increased. The average, ten years ago, even including warships, has now become the mean rate for the tramp steamer—530 ft. per minute, while many steamers for high speed attain to 880 ft., a few to 950 ft."

In regard to the question of firing, the closed stokehold system is now rarely used, the forced draught being delivered into the closed ashpit, as in the Howden system, or else there is an induced draught. Concerning mechanical stokers Mr. McKechnie has but little to say, except that there seems a wide field for them, especially if the water-tube boiler, with its large grate, comes into use. He refers to the experiments which have been made on the American great lakes, but really does not give this subject the attention which it really deserves. This is probably natural in a review of the past, but there is hope that before another decade the laborious work of stoking will be mainly performed by machinery.

High steam pressures have come into general use, and indeed there can be little or no gain expected with quadruple expansion with pressures below 220 pounds. This has brought in many difficulties in pipe and joint construction. Solid drawn and lap-welded steel tubing has largely replaced copper; valve boxes and bends being made of gun metal, flange joints being made with metal contacts or asbestos paper.

The development of power has been very marked during the decade under review.

"So far as high-speed machinery is concerned, the universal practice is to fit a four-crank engine operated from four cylinders, usually on the three-stage compound system, and occasionally for quadruple expansion, the cylinders being arranged on the Yarrow-Schlick-Tweedy system. Ten years ago the greatest power developed in any steamer was 20,000 indicated horse-power, and the highest speed on an over-sea voyage 20.7 knots. Now, 30,000 indicated horse-power is the highest in naval practice, the speed being 23 knots, while in merchant practice over 36,000 indicated horse-power has been developed, the mean speed on a transatlantic passage being 23.51 knots, while at the present time there is building a steamer to excel this splendid result. Full credit for this remarkable speed should be given to the company who built the vessel, the Stettiner Maschinenbau Actiengesellschaft "Vulcan," of Stettin, who have built for German owners the two fastest merchant vessels afloat, and are now building two to be at least equal in speed.

"The low-pressure cylinder was only occasionally divided ten years ago, and the greatest diameter was 113 in. In the case of the Campania such a division was made, and although the power was nearly 50 per cent. greater than in the ship with 113 in. low-pressure cylinders, the diameter of the largest cylinders was only 98 in. Experience has shown the enormous importance of balancing forces in the reducing of vibration, so that there has been a further encouragement to divide the third stage or fourth stage cylinders: always provided that tandem cylinders are arranged in couples to balance each other. In this way, even although the power has reached in one set of engines 18.000 indicated horse-power, the largest cylinder is only 106.3 in. against the 113 in. in the 10,000 indicated horse-power engine of ten years ago; the relative steam pressures being 220 lb. and 150 lb. Larger diameters are certainly not desirable, but there is no reason why with higher steam pressure a larger number of expansions should not be adopted with multiple cylinders, because any increase in the number of cranks tends to decrease the vibration. Multiple cranks with reciprocating weights can be so arranged as to minimise the disturbing forces, and the result in the case of the Deutschland is that the vertical vibration measured at the extremities of the 684 ft. ship was only 3/16 in."

In view of the frequent failures of tail-end shafts the rules for their dimensions have been modified to such an extent that according to Lloyd's rule the strength of propeller shafts has been increased 36 per cent. over that required in 1890.

A very important advance has been the greater attention given to the steam consumption of auxiliaries, and tests made on both sides of the Atlantic have showed the large proportion of steam used by the auxiliary machinery. The result has been a marked improvement in the construction of many of the auxiliaries, including the compounding of steam pumps and of engines for driving dynamos. In addition to this, the exhaust steam from the auxiliaries, instead of being delivered directly to the condenser, is passed first to the evaporators or feed water heaters, or delivered to the low pressure cylinder chests of the main engines, doing more work before passing to the condenser, with a resultant economy.

"In the ten years considerable progress has been made in the direction of speed. In 1891 there were only eight vessels whose speed exceeded 20 knots, now there are fifty-eight. The vessels between 19 and 19½ knots speed have doubled, numbering now thirty-four; and Great Britain, it is interesting to note, holds a high position, due in part to the number of high-speed Channel steamers in the Irish Sea, North Sea, and English Channel. The French, Belgian, and Holland high-speed steamers are principally Channel boats, but the five German vessels, and the four of the United States, are ocean liners. The highest speed attained ten years ago was 25 knots, recorded for a British-built Brazilian torpedo boat, the fastest British Navy torpedo boat being 22½ knots; now the record is held by the steam turbine-propelled destroyer Viper, of his Majesty's Navy, which has attained a maximum of 37.113 knots, and a mean for one hour of 36.581 knots. The highest ocean speed ten years ago was 20.7 knots, by the Paris and New York; to-day the highest speed on an ocean run has been achieved by the German liner Deutschland, which has maintained an average of 23.51 knots, while the best speed got with Chan-

nel steamers is that attained by the City of Dublin Steam Packet Company's steamers on the cross-Channel run—23.62 knots, with steam of 171 lb. pressure, the power being 8500. These vessels, of 3096 tons builder's measurement, have four-cylinder triple-expansion engines, with four double-ended boilers worked with closed stokeholds.

Mr. McKechnie gives a brief notice to the application of the steam turbine to marine propulsion, and hints that much depends upon the practical performance of the turbine vessel "King Edward."

Summarizing the results of the decade, the following features may be mentioned:

"Steam pressures have been increased in the merchant marine from 150lb. to 197 lb. per square inch, the maximum attained being 267 lb. per square inch, and 300 lb. in the naval service. The piston speed of mercantile machinery has gone up from 529 ft. to 654 ft. per minute, the maximum in merchant practice being about 900 ft., and in naval practice 960 ft. for large engines, and 1300 ft. in torpedo boat destroyers. Boilers also yield a greater power for a given service, and thus the average power per ton of machinery has gone up from an average of 6 to about 7 indicated horse-power per ton of machinery. The net result in respect of speed is that while ten years ago the highest sustained ocean speed was 20.7 knots, it is now 23.38 knots; the highest speed for large warships was 22 knots and is now 23 knots on a trial of double the duration of those of ten years ago; the maximum speed attained by any craft was 25 knots, as compared with 36.581 knots now; while the number of ships of over 20 knots was eight in 1891, and is fifty-eight now. But probably the result of most importance, because affecting every type of ship from the tramp to the greyhound, is the reduction in the coal consumption. Ten years ago the rate for ocean voyages was 1.75 lb. per horse-power per hour; to-day, in the most modern ships, it is about 1.5 lb. Ten years ago one ton of cargo was carried 100 miles for 10 lb. of fuel, whereas now, with the great increase in the size of ships and other mechanical improvements, the same work is done for about 4 lb. of coal—a result which means a very great saving when applied to the immense fleet of over-sea carriers throughout the world."

Automobiles and Aeronautics.

THERE appears to be little doubt that the present revival of dirigible balloons is in great measure due to the improvements which have been made in light, high-power motors because of the demand for automobile engines. It has long ago been shown that the prinicapl difficulty to be overcome in mechanical flight was the great weight of prime movers in proportion to their power, and it has been the partial solution of the question of light-motor construction which has rendered the modern automobile possible.

An article in a recent issue of the *Automotor Journal* upon the subject of the empire of the air, calls attention to the relation between the two departments of engineering effort, and some points there brought out demand notice and comment.

Modern flying machines are of two main kinds, balloons and aeroplanes, but both kinds have need of power to make them practical. The aeroplane is really a magnified kite, the power being applied to hold the plane surface in position just as the string holds the kite, while the balloon is nothing more than a drifting gas bag unless some propulsive machinery sufficiently effective to maintain steerage-way be added.

Such aeroplanes as have been constructed on an experimental scale, as Maxim's or Langley's, have found the engine problem their main difficulty, always remembering that the still uncertain matter of balancing and steering remains unsolved; while elaborate computations have been repeatedly made to prove that no balloon could ever carry motive enough to make even a few miles headway.

The Santos-Dumont balloon, however, is made with barely sufficient buoyancy to overcome the weight of its machinery, and demands the action of its motor to cause it to rise, and yet it is found that a 16 horse power motor is sufficient to drive it at a speed of upwards of 15 miles an hour, or against an equivalent wind resistance. At the same time it is the motor which has been the cause of most of its designer's difficulties, since it has failed him at certain critical moments, but thus far the questions of weight and motor capacity appear to have been definitely settled as within practicable limits, and the only portion

of the motive-power problem remaining is that of reliability and freedom of mishaps

The dirigible balloon should really be regarded as a similar construction to the submarine boat, the latter being made of about the same specific gravity as the medium in which it is operated, and dependent upon its motive power for its vertical as well as its horizontal movement.

It is evident therefore, that all efforts to produce satisfactory motors for automobile purposes are also contributing powerfully towards the solution of the question of aerial navigation, since the two main requirements, power and lightness, exist alike in both instances. The internal combustion motor has been given a high power per unit of weight by reason of the high pressure at which it operates, by the absence of the weight of any boilers, and by the high speed at which it is run. It is along these lines that further improvement must be made if any is to be expected, since they include the three elements of which power is composed, force (pressure) time, and distance (speed). The pressure limit is that of the strength of the materials employed, and this has not yet been carried to its extreme, since the latest and toughest alloys have not yet been used in motor construction. The speed limit has not yet been approached for rotative parts, since the steam turbine has set a pace which no reciprocating motor can approach. Rotary gas engines have been suggested, but as yet no practical information is available about them which would suggest the possibility of so improving them as to make them available. It does seem possible, however, that a gas turbine, running at the speed which some steam turbines have shown practicable, at pressures which are far above any yet used in automobile motors, should render results attainable in aerial navigation which, while not yet secured, are known to depend only upon the question of motive power.

The Construction of Naval Ordnance.

At the Barrow-in-Furness meeting of the Institution of Mechanical Engineers, an important paper was presented by Lieutenant A. Trevor Dawson upon the subject of naval ordnance. Stating the close relation of his subject with the work of the mechanical engineer, Lieutenant Dawson says: "Naval ordnance embraces most of the branches of the science of which the mechanical engineer is the master, and has this further importance: that upon its effective application to our fleet the Empire depends for supremacy, independence, almost for existence. It is true that there are other elements necessary to the fighting efficiency of a warship—speed, invulnerability and radius of action; but these vary according to the duty the ship has to perform, and with our vast Empire marching the territory and touching the susceptibilities of almost every power, such duties are many. Gunpowder, however, must always be a dominant factor, and there is only one class of naval ordnance suitable, and that the best obtainable for the purpose, irrespective almost of financial considerations."

The rate of progress in the armament of warships has been so rapid that some comparative new ships are decidedly inferior in gun power. Thus the "Diadem," launched only five years ago, has 16 6-inch guns, with a total energy of 158,592 foot-tons, while the "Hogue," launched in 1900, will have 12 6-inch guns and 2 9.2-inch guns, with a total energy of 296,516 foot-tons, or nearly double that of the earlier vessel. Since this rate of progress is not confined to British ships, but must be expected in the vessels which the British fleet may some day have to meet, it is most important that the pace should be kept, and that British vessels should not fall behind.

Passing from the military phase of the subject, Lieutenant Dawson proceeds to discuss the mechanical features of gun construction, and gives illustrations of the various types of British and foreign guns of strictly modern design.

Two general systems of construction are adopted by most naval powers—in the one the gun is entirely of steel and in the other of steel and wire. Great stress cannot be laid on the advantages of one system over the other, but it is probable that the highest possible efficiency in construction can be obtained by the proper application of wire, owing to the greater possibility of varying the tension of the wire and the tubes with greater theoretical accuracy that is possible with solid-steel construction.

Details of several of the most modern constructions are shown, taking the British 12-inch 40 calibre gun as an example, this being a wire wound gun with longitudinal stresses taken by the heavy inner tube, jacket, and breech ring. Other types are also shown. The breech block advocated by Lieutenant Dawson is the screw type, with the Welin form of screw, this with the plastic pad obturator enabling a fire of 11 rounds per minute to be attained with the 6-inch gun, and 8 rounds with the 7.5-inch gun, all the shots striking within a metre square of the target at a range of 1,100 yards.

Hydraulic power is to be preferred to steam, compressed air, or electricity for working large guns in barbettes or turrets, and details of approved arrangements are given in the original paper, showing British, American, and German practice. The American plan of superposed turrets is illustrated and described, and while its advantages are fully admitted, the disadvantages, especially as to the possible disabling of four guns at once, are considered to outweigh the merits.

It is impossible in the limits of space here available to examine in detail the mechanical features of the modern guns described in Lieutenant Dawson's papers, but his emphatic views upon the mooted question of submarine boats is especially interesting.

"Submarine boats bear on on the subject of naval ordnance—not so much in association with gunnery, but with torpedo armaments, which constitute a most serious factor in connection with our future naval history. Up to the present time the torpedo has been carried by most of our ships of war, but the maximum serviceability of the weapon must be obtained from such specially designed ships as the torpedo-boat or torpedo-boat destroyer. Now, however, a new field for the torpedo is opened out by the introduction of submarine or semi-submerged boats. Torpedoes are inoperative at a greater range than 2000 yards, and must be discharged within closer distance, so that in the case of two vessels even otherwise unequal, but armed with torpedoes, the chances of success will be equal, and thus it would be impolitic under most circumstances for the superior vessel to take the risk of being torpedoed. For this and other reasons mechanical torpedoes should be utilised by specially constructed vessels, and particularly by boats capable of remaining unseen except for momentary reappearances to take observation. This is a condition easily fulfilled by a submarine boat much more efficiently than by torpedo-boats of the ordinary type. Attack by daylight would make them almost certain victims of any ship armed with a moderately heavy quick-firing gun, escape being impossible; whereas the submarine boat, if discovered when porpoise-like she comes to the surface, can immediately dive, cruise under water for a few miles, and make her escape, to fight another day.

"At the present time the French have thirty-four boats in various states of manufacture, twenty-nine of which are electric submarines and five submersibles, and they are now carrying out important trials and spending large sums of money in their development. Before many years have passed France will have not thirty-four but hundreds, with which she would be able not only to protect her ports, but to make attacks on our fleet in much the same way as the bands of Boers are making guerilla attacks on our regular army in the Transvaal. Of the continuous stream of ships passing up and down the English Channel —the busiest steamship track on the globe —quite 90 per cent. are British vessels, and upon them our mercantile greatness depends. Let us suppose that in time of war 100 French submarines were let loose in the Channel at night. These boats have sufficient speed and radius of action to place themselves in the trade routes before the darkness gives place to day and they would be capable of doing almost incalculable destruction against unsuspecting and defenceless victims. The same applies to the Mediterranean and other ocean highways within the danger zone of the submarine.

The Minerva and Hyacinth Trials.

WE have already commented upon the trials of the boilers of the Minerva and Hyacinth in the last issue, and now we have the official report of the runs to Gibraltar and back, with comments by the Controller of the Navy in forwarding the report to the First Lord of the Admiralty.

Since the results have already been fully

discussed, and the absence of their value shown to be largely due to the stage of the game at which they were made, there is but little comment to be made upon the report at this time. It is of interest to note, however, that the assumed slowness with which steam can be raised in Scotch boilers was shown never to have had any real foundation, this little incident forcibly reminding us of the anecdote of King Charles II and the goldfish; while the mysterious capacity of the Belleville for receiving water of which no possible account could afterwards be given, either as steam or as leakage, appears to be officially confirmed, but not officially explained.

Just what will be done with the report remains to be seen, and in the meantime the condition of the question of boilers for the navy will continue to remain in the same state of glorious uncertainty which has characterised it for the past year.

A Study of the Electrical Coherer.

In all the experimental and practical work which has been done in space telegraphy it has been realised that it is the coherer which is the fundamental essential of the system, and hence anything which increases our knowledge of this little tube of filings and its behaviour under the influence of electrical waves is of importance and interest. A recent paper by Dr. W. H. Eccles, published in the *Electrician*, gives the results of numerous careful experiments with a great number of coherers, and the discussion of these enables him to deduce a theory of their action which is at least interesting and may prove of practical value.

Dr. Eccles gives a brief historical résumé of the development of the coherer, and although numerous earlier experiments upon the influence of electrical currents upon finely divided metals had been made, he gives fair credit to Professor Branly for having described in 1891, what may be fairly understood as a coherer in the modern sense of the term.

Briefly, as is now generally understood, a coherer consists of a tube of glass containing between two terminals a mass of finely divided metallic particles, usually in the form of filings, these particles having such a high resistance as to prevent the passage of a current in the circuit of which they form a part. Under the influence of the electro-magnetic waves produced by an electric discharge, such as the spark between the terminals of an induction coil, even at a considerable distance, these metallic particles "cohere", or permit, in some way not yet fully understood, the passage of the current. Upon tapping the tube, or otherwise disarranging the particles, the property of conductivity is removed, only to be re-produced by the action of a succeeding wave, and thus signals made by successive electric sparks or discharges, may be transmitted over space and received by an apparatus placed in the circuit of which the coherer forms a part.

Dr. Eccles limits his investigations to coherers made with filings, and by subjecting them to various potentials he endeavoured to discover some logical theory upon which to base their action.

"The phenomenon of coherence, whatever it may consist in—whether it is, as Lodge affirms, a welding together of the two surfaces in pseudo-contact, a reaching of the forces of cohesion across the separating space; or whether it is, as Branly considers, a modification of the dielectric occupying the minute space between the conductors concerned; or, as Bose has proposed, an effect depending on allotropic change in the material of the conducting particles; or, as others believe, one depending on the existence of surface films of condensed gases or moisture—this phenomenon of pure coherence is, in all probability, greatly disguised and complicated in a filings coherer by the preliminary and purely mechanical actions of the particles. That the phenomenon of coherence proper, then, cannot be advantageously studied amid these probable complications need scarcely be pointed out. This view of the case seems also to the writer to account in a great measure for the extraordinary conflict of opinion which has obtained, since Branly's discovery, with regard to various qualities, such as the relative sensitiveness, of coherers made with filings of different metals. To cite only a few cases, it is notable that Marconi, in his patent specification of March, 1897, states that he uses a proportion of silver filings to increase the sensitiveness of his nickel coherers, and that the continued addition of silver greatly increases the sensitiveness;

while Lodge, in the same year, remarked that the noble metals are not suited for coherers. Dorn, in 1898, confirmed Lodge, and with the noble metals placed nickel, adding that only oxidisable metals are sensitive. Branly then announced that, on the contrary, the noble metals are extremely sensitive; and Blondel and Dobkevitch seem to agree with Branly when they state that the less oxidisable metals give lower critical voltages.

"Such confusion has arisen, the writer believes, out of the great complexity of the numerous conditions which influence the mechanical and electrical behaviour of the filings in a coherer. These conditions may be seen to be dependent, broadly, on the state of rest or of motion of the particles and on their relative positions at the moment of coherence; on the nature, probably, of the material of which the filings consist; and on the size and shape of the filings. Evidently the size and shape of the particles each depend on the manner of production—that is, on the kind of file used and the mode of using it, and must also be, for different substances, to some extent dependent on the elasticities, the tenacity, and other properties of those substances. The mechanical circumstances alone are thus extremely involved. But to co-ordinate the experimental data accumulated by the author it was early found necessary to construct a working theory. This theory springs naturally from the results of the first few series of experiments. That these experiments were necessary for the framing of any hypothesis intended to correlate the movements of the particles with the E. M. F.s applied is evident. For, if oscillatory discharges were proved necessary for efficient coherence—that is, in the light of Tommasina's experiment for the formation of numerous chains of cohered particles—then the effect on the movements of the particles of displacement currents in the dielectric must be taken into account; while if, on the contrary, steady E. M. F.s were shown sufficient, then other electro-mechanical connections must be proposed."

After many experiments which gave discordant results, Dr. Eccles finally worked with an apparatus which subjected the coherer under examination to a continuous moderate tapping of about 50 vibrations per second. The coherer was then submitted to known electromotive forces taken from a potentiometer, and the corresponding galvanometer deflections were tabulated and plotted in the form of curves. Details of many of these investigations, together with the results, are given in the original paper, and these all go to confirm the fact that the oscillation of the potential difference is not the cause of the conductivity of the coherer, but that it is due merely to the difference of potential. It is therefore necessary, in practical space telegraphy only to produce the necessary difference in potential.

So far as a theory of the action of the particles in the coherer is concerned, Dr. Eccles inclines toward that of Lodge, with a modification. Assuming that there is a true coherence, he also believes that a mechanical action, depending on the form of the particles takes place, and that this latter is very important. Attempts to sort out the filings by sifting, etc., to obtain such as were truly spherical, as contrasted with those which were elliptical, or irregular, were not successful, and the difficulties in this work are indeed great. At the same time it is altogether probable that the particles tend to place themselves axially with regard to the field, although this cannot be entirely demonstrated.

Electric Power and Industrial Prosperity.

It is generally admitted that national prosperity is closely bound up with the development of technical industry, and this again depends upon the wise use of natural forces, directing them so as to obtain the greatest results with the least expenditure.

The relation of the application of electric power to industrial prosperity is discussed at length in a paper by D. N. Dunlop in recent issues of the *Iron and Coal Trades Review*, and the importance of the introduction of electric driving emphasised. That this introduction has been greatly delayed in the case of British workshops is held to be due to four main reasons:

1. Want of Capital.
2. Excess of caution in investing the capital in electric plants and appliances
3. Disinclination to scrap existing machinery.
4. Lamentable lack of technical knowledge in both employers and employed.

Since Great Britain is now entering upon a century in which she has the active competition of powerful and active nations where she formerly possessed unmolested supremacy, it is most necessary that she should employ the most advantageous methods if she is to hold her own. In the opinion of Mr. Dunlop, victory in the inevitable twentieth-century struggle for commercial and industrial supremacy will surely fall to that nation which is able to make the best use of electric power, and which displays the greatest ingenuity in bringing about by its means economy in labour and increase in output.

The practicability of electric driving is now so fully assured that no demonstration is really necessary, although Mr. Dunlop cites numerous instances of the success with which it has been applied to all kinds of machinery in various parts of the world. Formerly it was thought to be all right for driving small printing presses or other light machinery but out of the question for heavy tools and similar appliances. To-day it is in successful use for operating heavy mine pumps, 100 ton cranes, 70-inch lathes and other heavy machine tools, while every electric tramway is a conspicuous example of heavy electric driving and transmission under most trying conditions.

Leaving then the question of practicability as being fully and admittedly solved, the question of commercial advantage remains; it being assumed that economy in the final cost of the product is the ultimate result to be attained. That electric driving possesses the elements required for commercial economy is summed up in the following advantages: Saving in power, labour, fuel, and repairs; in the cost of buildings, equipment, and clear head room; freedom in the arrangement of machinery and shops, in the growth of premises and distribution of power; a more satisfactory control of speed; great increase in output, in the health bill and cleanliness, and less serious shut-downs for repairs.

The saving in power is mainly due to the economy in transmission, this being the most serious source of loss under the older systems of driving. There is no space here to go into details, but carefully considered figures, collated from many and varied sources, place the saving due to the use of electric power to about 20 per cent. This is in the bare cost of the power itself, and does not include its more efficient application.

The removal of overhead shafting and belting permits the general use of overhead travelling cranes, while the fact that electric power is readily available in all parts of the establishment renders the use of all kinds of handling machinery to replace manual labour. Thus the pay roll is reduced while at the same time the work is more quickly performed and the total output is increased. Herein lies one of the most marked causes of economy. It is generally admitted that the fixed charges of an establishment, interest, depreciation, taxes, motive power, office charges, etc., are about equal to the total pay roll, under the old system, these charges therefore forming about 50 per cent. of the total shop cost of the product. If by the use of electric driving the total output can be increased for the same fixed charges, the percentage of cost on this account is proportionally reduced, and this is one of the advantages of the increased output obtained by the employment of electric driving.

It is admitted that the initial cost of a plant with electric driving is somewhat higher than an equipment of shafting and belting, but this is more than compensated for by the increased advantage with which floor space can be utilised. It has been estimated that the Baldwin Locomotive Works would require 40 per cent. more floor space were it not for the space economy which is secured by electric driving, enabling, as it does, all parts to be equally available for power driven machinery.

The substitution of electric power for nearly all labourious handling reduces the labour cost and at the same time eliminates only the lower class of labour.

"Far from man becoming a mere tool himself when attendance on the machines replaces physical manual labour, the intelligent workman receives a strong stimulus to give his work and the product of the machine his deepest thought, and to endeavour to understand and learn something of the wonders of electricity. There is nothing that reduces a human being more quickly to the level of a machine than constantly repeated physical movement which requires no thought."

The Commercial Production of Oxygen.

With the development of improved processes for the production of oxygen the possibility of extending its uses in the arts naturally appears, and from a paper recently presented by the well-known scientist, M. Raoul Pictet, before the *Société des Ingénieurs Civils de France*, and published in the *Mémoires* of the *Société*, some interesting data on this subject are found.

The old laboratory methods of producing oxygen by heating some of the compounds from which it is most readily separated, are altogether too expensive for extensive employment on a commercial scale, and hence the methods which have been investigated in recent years have had for their end the isolation of the oxygen contained in the atmosphere.

Nearly thirty years ago, the chemist Tessié du Motay invented a method of separating the oxygen of the air by the employment of the oxide of barium. A current of air passed over baryta at a high pressure and moderate increase in temperature produces a binoxide of barium, the oxygen being absorbed from the air. When the pressure is removed the oxygen spontaneously disengages itself and may be collected in a receiver, while the baryta may be used again, thus playing the part of a sponge, which absorbs oxygen at a moderate temperature and high pressure and permits it to escape at a low pressure and higher temperature. Other alkaline metals, such as magnesia, have been used in similar processes, but the cost has in all cases been too high to enable oxygen to be made in commercial quantity.

With the introduction of liquid air, a new method of separating atmospheric oxygen has been made possible. This is based upon the fact that oxygen and nitrogen have different boiling points, and since nitrogen has the lower boiling point it is possible to permit it to boil away from liquid air first, leaving the liquefied oxygen behind. The fact has been carefully verified by experiment that the boiling point of liquid oxygen under atmospheric pressure is —183° C. while that of nitrogen is —195° C. There is therefore a difference of 12° C. in the boiling points of the two gases, and by slowly warming a quantity of liquid air the nitrogen will vaporise first, leaving behind pure liquid oxygen.

Many investigators have sought to find in these facts the source of cheap oxygen, but the high cost of liquid air must bar its direct use for this purpose.

M. Pictet, however, has devised a new and most interesting application of this principle, which bids fair to make cheap oxygen an established fact, and from his paper above referred to we abstract a brief account of his method. He employs liquid air, indeed, but instead of using the extravagant method of making large quantities of liquid air by the Linde process, or some of its modifications, he requires but an original charge of liquid air, and constantly renews this by the action of his process of procuring pure oxygen.

In order to understand how this can be accomplished it will be advisable to examine more closely the process of fractional distillation of liquid air.

In the change of state from the liquid to the gaseous, the nitrogen and oxygen of which the liquid air is mainly composed, absorb heat from their surroundings. If these surroundings can be made to consist almost entirely of atmospheric air, this air jacket will be reduced in temperature, losing as much heat as is required for the vaporisation of the original volume of liquid air. All that would then be necessary is a compressor to reduce the cooled air to the liquid state.

This, then, is the principle of Pictet's new process for the production of liquid oxygen. An initial mass of liquid air is boiled by the heat delivered to it by a current of atmospheric air, this air first passing through

a spiral pipe coiled around the reservoir containing the liquid air and then through a second spiral immersed in the liquid. The liquid air slowly evaporates, the pure nitrogen first coming off, followed, as the temperature rises, by mixed nitrogen and oxygen, until finally pure oxygen comes off. In the mean time the air which has passed through the spiral pipes has been lowered in temperature to the critical point, and requires but a feeble pressure to reduce it to the liquid state, and this pressure being supplied by a pump, there is obtained a supply of liquid air equal in volume to that with which the operation was started.

This can be repeated indefinitely, and as the apparatus can readily be arranged so as to render the operation continuous, we have as the only energy expended to produce the distilled gases that required to drive the compressing pump. Thus the quantity of liquid air which is evaporated each instant is replaced by an equal quantity, and no new supply is necessary.

It will be seen how at once this renders cheap oxygen a possibility. M. Pictet gives in his paper the elements of cost, and shows that oxygen 90 per cent. pure can be produced in commercial quantities at a cost of only 0.013 franc per cubic metre, or less than the selling price of common illuminating gas!

M. Pictet calls attention to the fact that in liquefying air there is produced a quantity of solidified carbonic acid, and this is separated from the liquid by filtering. If the air used in his process be mixed with carbonic acid, readily obtained from the waste furnace gases, a large quantity of solidified carbonic acid is produced as a by-product, and as this has a steady market value, its sale is sufficient to defray all the cost of producing the oxygen, which is itself thus made the by-product. In the working apparatus the evaporated gases are collected in three holders, one containing pure nitrogen, the second for the mixed gases, containing about 50 per cent. of oxygen, and the third for the oxygen, about 90 to 95 per cent. pure.

The operation of the apparatus was shown before the *Société* in complete working order, and in his paper M. Pictet gives the detailed thermodynamic computations of the heat interchanges, showing the full accordance of the process with theory.

The possession of cheap oxygen means a complete revolution in many technical processes, and M. Pictet details a few of its applications; while many others will surely be developed.

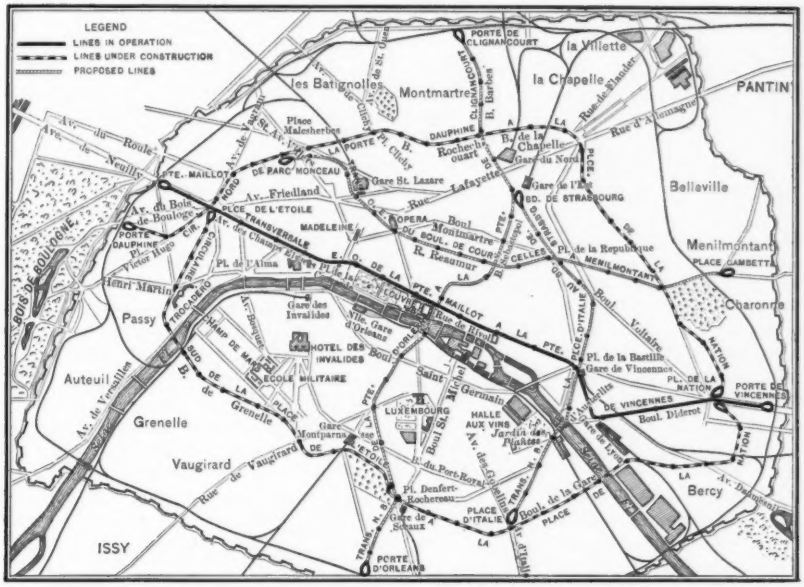
In connection with metallurgy many applications are suggested. Injected into furnaces it will produce the complete combustion of carbon, with intense localisation of heat, if so desired. Used in connection with the vapour of water it gives the most powerful reducing agents known, i. e., carbon monoxide and pure hydrogen, thus enabling the removal of all the injurious metalloids commonly associated with iron, such as phosphorus, sulphur, arsenic, etc.

In connection with forge work the use of oxygen would permit an enormous saving of heat, due to the absence of the diluting nitrogen of the atmosphere, enabling temperatures of 2,200° to 2,400° C. to be quickly attained. The use of the oxy-hydrogen blowpipe becomes a commercial possibility for large work, and welded seams and joints for structural work may in many cases replace riveting.

In chemical technology its applications will be innumerable, and in medicine, any reduction in the price of pure oxygen will be hailed with delight, and instead of being used as a last resort, it will be freely employed for innumerable purposes.

An important application appears in connection with incandescent gas lighting. By burning water gas and pure oxygen the incandescent mantle can be caused to emit a far more brilliant light than is possible with an air-fed burner, while the high temperature thus obtained will render the mantle vastly more durable than with the feebler heat. For more brilliant lighting the oxy-hydrogen light, using cylinders of lime or zircon, becomes commercially possible, while the acetylene flame, fed with pure oxygen becomes far brighter than before, and all deposits which tend to clog the burners disappear.

The well-known reputation of M. Pictet as a careful and conservative scientist, and the high standing of the body before which his demonstrations were made, render this paper one of especial weight and importance, demanding instant attention.


LEGEND
LINES IN OPERATION
LINES UNDER CONSTRUCTION
PROPOSED LINES
Les Batignolles
Montmartre
la Villette
la Chapelle
PANTIN
Belleville
Menilmontant
Charonne
Passy
Auteuil
Grenelle
Vaugirard
Bercy
ISSY
Bois de Boulogne
Av. du Roule
Av. de Neuilly
Av. de Versailles
Av. de St. Ouen
Av. de Clichy
Av. Friedland
Av. du Bois de Boulogne
Av. Victor Hugo
Av. de Trocadéro
Av. de Wagram
Av. de la Grande Armée
Av. de Suffren
Av. de Breteuil
Av. de Saxe
Av. de Ségur
Av. de Villars
Av. de la Motte Picquet
Av. de Lowendal
Av. de la Bourdonnais
Av. de Tourville
Av. de la Dernière Cartouche
Av. de Lamothe Piquet
Av. de Mac Mahon
Av. de la Grande Armée
Av. de Malakoff
Av. de Friedland
Av. de Messine
Av. de Hoche
Av. de Villiers
Av. de Clichy
Av. de St. Ouen
Av. de la Porte de Clignancourt
Av. de la Porte de St. Ouen
Av. de la Porte de Clichy
Av. de la Porte de Champerret
Av. de la Porte de Neuilly
Av. de la Porte de Maillot
Av. de la Porte de Villiers
Av. de la Porte de Courcelles
Av. de la Porte de Monceau
Av. de la Porte de Wagram
Av. de la Porte de Clignancourt
Av. de la Porte de la Chapelle
Av. de la Porte de la Villette
Av. de la Porte de Pantin
Av. de la Porte de Bagnolet
Av. de la Porte de Charonne
Av. de la Porte de Vincennes
Av. de la Porte de Picpus
Av. de la Porte de Reuilly
Av. de la Porte de Bercy
Av. de la Porte de Charenton
Av. de la Porte de Ivry
Av. de la Porte de Gentilly
Av. de la Porte de Montrouge
Av. de la Porte de Vanves
Av. de la Porte de Versailles
Av. de la Porte de Sèvres
Av. de la Porte de Passy
Av. de la Porte de Auteuil
Av. de la Porte de Boulogne
Av. de la Porte de Neuilly
Av. de la Porte de Maillot
Av. de la Porte de Wagram
Av. de la Porte de Clichy
Av. de la Porte de St. Ouen

circle or ring line, this portion touching the principal railway stations and such important centres as the Place de la Nation, Place d'Italie, Place Denfert-Rochereau, Trocadéro, Place d' Etoile, and the Párc Monceau. The remaining portions of the system are clearly shown on the map, and include two north and south lines, and an additional east and west line.

It can readily be seen that such a comprehensive scheme is far superior to any combination of independently designed and constructed roads, to say nothing of the advantages resulting from the systematic cooperation of the various sections.

The experience which has been had during the year's operation of the first section has revealed a number of points which are of influence in modifying the actual working of the road. It has been found impracticable to run the trains on a closer headway than two-and-a-half minutes, and indeed the actual timing at present is three minutes, while the traffic upon this section is such that there is no practicability of reducing the number of trains. This being the case, there will be no opportunity of running connecting trains from the new sections, when completed, in between the trains on the present schedule of the Porte Maillot—Vincennes section. The original plan of having the various sections combined to form a number of closed circuits, with trains running continuously in each direction, has necessarily been modified, and each section will now terminate in a loop at each end, as is shown on the map. Each section is therefore to have its own trains, these trains being run back and forth over the various sections, thus avoiding the difficult problem of running trains of various sections upon each other's tracks for any portion of time.

Modern War-Ship Construction.

WITH the comparatively recent entrance of Germany into ship-building and marine engineering there has naturally developed a special interest in naval construction, and hence the paper of Chief Naval Constructor Hüllman, presented before the recent meeting of the *Verein deutscher Ingenieure* at Kiel, and published in the *Zeitschrift* of the society, demands comment, treating as it does of the general principles of the design of warships in accordance with present German practice.

Like nearly every engineering structure, a warship is a compromise between a number of conflicting conditions. Thus there should be a minimum displacement, and at the same time the maximum of powerful military equipment with its consequent weight. The hull should possess the greatest possible strength and rigidity, with power to stand injuries without being disabled, and yet the vessel itself should form as small a proportion of the total displacement weight as possible, leaving as much as possible for armament and machinery. The speed should be a maximum, consistent with the branch of service for which the vessel is intended, and at the same time the hull must be given a broader beam and fuller lines than are consistent with high speed, in order to provide a sufficiently stable gun platform. A large coal capacity is necessary in order to provide an extended steaming radius, while at the same time it must be realized that every ton of coal carried means a ton less available for armour and equipment. When to these fighting qualities are added the desirability of producing a vessel of good sea-going qualities, having comfortable living quarters for officers and crew, it will be seen that the task of proportioning the relative weight of all these conflicting conditions is by no means a light one.

In earlier times, before the advent of steam propulsion, the problem was a much simpler one, the armament being the principal characteristic, the type being named for the number of guns carried. With the introduction of a steam power and armored protection, however, came the many complications of the modern war ship, and to-day all the ingenuity of the engineer and naval architect is required to produce even a partially satisfactory result.

Reviewing the development of German naval construction during the past thirty years, Herr Hüllman examines the general advances which have been made during that period. In the case of the first heavy armoured cruiser, "Konig Wilhelm," (1868), the weight of the hull formed 44 per cent. of the total displacement, while at the present time the hull weight has been reduced to about 31 per cent., while at the same time

the strength, stiffness, and security have been greatly increased.

The question of the increase in the size of warships is somewhat different from that of the merchant marine. In the case of the merchant vessel the advantages of size are obvious, the cost of operation increasing at a far slower rate than the increase in profitable carrying capacity. For the warship, however, there are two sides to be considered. Doubtless the larger vessel has a greater speed per ton of propelling machinery carried, and is capable of bearing heavier armament, so that to-day battle ships are rarely of less than 12,000 tons displacement, while thus far a displacement of 16,000 tons has not been attained. It must be remembered, however, that in naval warfare, large ships mean large tactical units, and that the loss of a single vessel in an engagement means a correspondingly greater injury to the strength of a fleet.

One of the most important questions is that of the proper powering in order that the desired speed may be surely attained. The laws governing the resistance of water are as yet too imperfectly known to enable satisfactory mathematical formulas to be deduced, and it is most desirable that the powering of vessels should be based upon experimental models in testing tanks. Since the first experiments of Froude in England in the early 70's, tanks have been built in various countries, notably by the United States Government at the Navy Yard at Washington, but in Germany there is as yet no government tank, although one has recently been constructed at Bremerhaven by the North German Lloyd Company, for use in connection with the powering of the fast ocean liners under construction for its service.

The demands for increased speeds make corresponding requirements for greater powering, and this has necessarily imposed conditions of weight for machinery which have taxed the ability of marine engineers to the utmost. The principal means which have been adopted for obtaining the maximum power with the minimum weight of machinery, have been higher steam pressures, with the use of lighter, water-tube boilers, and higher piston speeds. In this way it has been found possible to reduce the weight of the engines of battleships of 100 kilogrammes per indicated horse power, by one-third to one-half.

Herr Hüllman goes into the general routine of the design and construction of a warship so far as the limits of a professional paper will permit, and his discussion only emphasizes the fact which is too often overlooked in military circles, that a modern battleship is indeed a fighting machine, and that there is almost nothing left of the work of the old-time shipbuilder or of the duties of the old-time sailor. That such a machine, primarily built for the purpose of mechanical fighting, should be controlled by others than engineers is one of the anomalies of modern warfare, but it may require more than one disastrous conflict for this truth to be driven home to the powers which control military and naval organisation. The nation which first perceives this, and which equips its land and sea forces with modern machinery, operated solely by engineers and machinists, throwing overboard all that pertains to mediaeval militarism, officialism, and bureaucracy, will exhibit such an overpowering supremacy in the time of conflict that the death knell of epaulet-wearing martinets will be sounded everywhere.

Air Brakes for High-Speed Trains.

In considering the question of high-speed trains the problem has generally been considered to be the best method of producing and maintaining the desired speed, but it is almost as important to consider the stopping of the train as the moving of it. The importance of the brake as an element of control has more especially appeared in some of the projects for extremely rapid electric trains, and in a paper recently presented before the *Verein Deutscher Maschinen Ingenieure* by Herr Wagner, and published in *Glaser's Annalen*, the experiments conducted with electrically operated air brakes for the Berlin-Jüterbog military railway are discussed at length.

When the conservative conditions of safety are considered, it is found on the German railways that the continuous pneumatic brakes are not available for trains of more than 60 axles. This practically limits the use of such brakes at high speeds to ordinary passenger trains, and hence for the new military road, which is to be regularly

equipped with trains of 110 axles, some modification has been demanded.

The improved brake, tests of which were described by Herr Wagner, is the electric modification by Siemens & Halske, of the well-known Westinghouse air brake, the change being in the substitution of an electro-magnetic device in the place of the triple valve.

Briefly the principle of the Westinghouse brake is the use of the air pressure to maintain a supply of compressed air in auxiliary reservoirs under each car, and at the same time keep this air from acting on the brake cylinders until the pressure in the air main is reduced by the operation of the engineer's valve. The triple valve is arranged so as to be operated by the reduction of pressure in the air main throwing each auxiliary air reservoir into connection with the brake cylinder of its especial car. The duration of the time required for the application of the brakes is therefore that which is necessary for a reduction of pressure in the air mains to act upon all the triple valves throughout the train, and as the contents of the air main is but small the action is very prompt.

The Siemens & Halske modification retains the auxiliary reservoirs of compressed air by each brake-cylinder, but replaces the triple valve by a valve operated by an electro-magnet, the magnets of all the cars on the train being in the same circuit, and the valves being operated instantaneously and simultaneously, whatever the length of the train. The air main is required only to maintain the air pressure in the auxiliary reservoirs, the valves being opened and the brakes set instantaneously throughout the entire length of the train merely by making a single electric contact. This renders the consideration of the length of the train altogether unnecessary, since the time required for the current to traverse the length of the longest train is absolutely inappreciable.

The idea of operating pneumatic brakes by electrical control is by no means new, but the details of the Siemens & Halske apparatus have been well worked out, and the fact that this system has been found acceptable for a road of such interest as the new German military express railway, makes its trials especially important.

The trials were made with the recording apparatus of Kapteyn, by means of which the time is marked automatically in seconds upon a moving strip of paper, while at the same time the distance traveled by the train is recorded from the moment of the application of the brakes until the train is brought to a standstill. The record was also arranged to show the time required for the attainment of full pressure in all the brake cylinders of the various cars of the train, thus enabling reliable comparative records of the pneumatic and electric control to be obtained.

For the full records and tabulated results of the trials the reader must be referred to the original paper, but it appears that in all cases the superior promptness of the electric control was made clearly manifest; in general the train was stopped in about one-half the distance by the electric control than was required with the pneumatic control.

Electric Locomotives on the Orleans Railway.

THE extension of the Orleans Railway from its former terminus in Paris at the Place Valhubert by the Pont d'Austerlitz to the new station on the Quai d'Orsay has already been fully described in THE ENGINEERING MAGAZINE, and the manner in which the new station in the very heart of Paris is reached by means of a subway running along the left bank of the Seine was fully illustrated in the article by Professor Jacques Boyer in the issue for April, 1899.

Since the use of steam locomotives, filling the subway with smoke and gases, and fouling the atmosphere of the quays above was not countenanced for a moment by such a well-conducted city as Paris, it became necessary to resort to electric traction for the new section of the railway. This electric service has now been in service for nearly a year, and from an article in a recent issue of *La Revue Technique*, we abstract some data and information concerning the working of the electric locomotives on this section.

The locomotives themselves present nothing demanding especial comment, being equipped with General Electric motors and provided with series-parallel controllers of

the Thomson-Houston type. The total weight of one of these locomotives is 45 tons, the wheel-base being 6 metres. There are four motors, of 275 horse power each, giving sufficient tractive power to haul a train of 300 tons up a 1 per cent. grade, and such trains are regularly hauled from the old Austerlitz station to the new one on the Quai d'Orsay, a distance of 4 kilometres, in less than seven minutes.

There are eight of these locomotives in the regular service of the subway, handling about 200 trains daily with every satisfaction, the trains being taken by steam locomotives upon their arrival at the Austerlitz station.

When it is remembered that the Orleans Railway is one of the most important in France, operating, with its various branches nearly 7,000 kilometres of track, forming a network over the south and southwest of France, it will be seen that this is a valuable precedent for other great cities which have allowed steam traction, with all its accompanying nuisances of smoke, gas, and heat, to obtain a hold. Any pleas as to the impracticability of introducing electric traction within city limits, in connection with steam traction without, may well be met with a reference to the manner in which the Orleans Railway is handling 200 trains a day of local and through traffic with but eight locomotives, through the heart of Paris.

The Performance of Shearing Tools.

In the July issue we referred in these columns to the study of the performance of shearing tools, as discussed by M. Codron, in the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, and now we have a continuation of these important researches in a later issue of the same publication.

In that portion of the work already reviewed there was considered the action of a single cutting tool, such as a chisel, acting as a wedge to separate the bar of metal upon which it is forced into two parts. This is a comparatively simple problem, since the forces may be decomposed according to well-known methods of mechanics, the only really indeterminate element being the friction upon the rubbing surfaces of the tool and the metal.

In extending his investigations to double opposing shearing tools, in the article now under consideration, M. Codron enters upon a more complicated phase of the problem. Those who are familiar with the appearance of a freshly sheared section as the bar falls from a double acting power shear, will observe that the actual cutting action of the tools as indicated by the brightly cut surfaces, extends but a short distance into the section on either edge, the remainder of the section evidently having been ruptured by the forcible sliding of the fibres upon each other.

The forces which effect this rupture are of a complex character, partaking more or less of the nature of tearing, bending, and sliding, according to the character of the material.

Considering first cold shearing, M. Codron analyses the manner in which the internal layers of the metal are deformed by compression while the outer layers are actually cut through to a certain depth.

The line passing through the points of greatest deformation is then seen to be a sinuous curve, extending between the two cutting edges, an oblique sliding taking place along this line as soon as the fibres have their ultimate resistance exceeded.

The resistance to shearing is well shown by plotting the pressures and the penetrations in the form of a curve, and this, in the example given of a bar of iron 60 mm. square, shows a continually increasing resistance during the actual shearing, attaining a pressure of 90,000 kilogrammes for a penetration of about 8 millimetres on each side. This pressure was partly occupied in forcing the shearing edges into the metal, and partly in compressing the internal fibres of the bar. From that point the pressure rapidly fell, the inner fibres yielding and sliding upon each other with a continually diminishing resistance, until, with penetrations of about 18mm., the bar fell apart. The mean pressure for the entire cut was about 75 kilogrammes per square millimetre (about 107,000 pounds per square inch).

The relative extent of the cutting and rending action depends largely upon the ductility of the material. Such a substance as rubber, for example, permits such a great degree of compression without rend-

ing that the two cutting edges practically meet and shear the compressed section, without tearing it. A similar action takes place in hot shearing, the heating producing a degree of ductility similar to that possessed by the cold rubber.

The contrary action is naturally found to exist with hard steels, the relation of the sheared sections to the torn portion being much greater with a hard tool steel than with a ductile wrought iron.

As a result of a large number of experiments, M. Codron finds that the pressure required for shearing is practically proportional to the section of the bar, the pressure required being equal to a constant, multiplied by the width of the cut and by the thickness of the bar, the constant depending upon the nature of the material to be sheared.

Cut-off and Compression in Steam Engines.

On several occasions attention has been called in these columns to the important researches of Professor Dwelshauvers-Dery, of the University of Liége, upon the action of compression in steam-engine cylinders; and we now have another important communication from him in a recent issue of the *Revue de Mécanique.*

In order to restate his position, a few words of explanation may be appropriate.

It has generally been assumed, following the dictum of Zeuner, that the injurious effect due to clearance in the steam cylinder, could be neutralised in practice by increasing the compression to such an extent that the pressure so produced equalled the initial pressure; the incoming steam not being delivered into an empty clearance space, but finding that space already filled with steam compressed to boiler pressure.

About two years ago, Professor Dwelshauvers announced that his investigations upon the experimental engine in the laboratory of the University of Liége failed to sustain the view of Zeuner, and his experiments certainly appeared to show that with large clearances no practicable degree of compression would compensate for the clearance.

The publication of these results was followed by much comment and discussion, and the general opinion has been one of distrust in the reliability of the experiments, notwithstanding the eminence of the professor, and the completeness of his laboratory equipment. Professor Dwelshauvers himself, on the contrary has had ample faith in the correctness of his experimental results, and has attempted to explain the apparently anomalous results by the effect of cylinder condensation upon the compressed steam. That cylinder condensation plays an important part in the problem is admitted, but since it has openly been maintained by some that the main phenomena discussed by Professor Dwelshauvers were due to leakage in his experimental engine, he has naturally been expected to show that such was not the case.

So far as the question of leakage is concerned, the experimental engine at Liege has been most carefully examined in order to detect any possible influence from this cause upon the experiments. The most conclusive test is the following: When steam is compressed in the clearance space of an engine the pressure rises in a curve, as shown on the indicator diagram. If, at the proper point in the compression, the admission port is opened, giving lead, the live steam entering produces a pressure which joins with the compression to produce a smooth and continuous curve. If the live steam is not admitted soon enough the pressure due to compression ceases to rise, and there is a drop in the compression curve, forming a hook. This hook has been supposed by some to indicate leakage, but Professor Dwelshauvers maintains that the drop of pressure is solely due to condensation, heat being imparted to the cylinder walls more rapidly as the pressure rises. After having made tests with the engine and producing this hook upon the indicator cards, using steam in the engine, it was operated with compressed air, the engine being driven by a motor, and the air drawn in and compressed to the same degree as the steam had been. In this case the compression curve followed the steam compression curve up to a certain point, but then continued on smoothly upward, there being no hook whatever produced. Had the hook in the curve been due to leakage, it would have been produced equally with the steam and the air, but its absence with the non-condensible fluid disposes effectually of the leakage theory.

The Treatment of Tool Steel.

THERE have been various statements in the engineering journals about the remarkable properties of an improved tool steel introduced at the works of the Bethlehem Steel Works, by Messrs. Taylor and White, but until now there has been no authoritative publication concerning the nature of the steel and the method of its preparation. For this reason the paper of Mr. Charles Day, recently presented at a meeting of the Franklin Institute, and published in the *Journal* of the Institute, demands especial comment.

Before examining the special composition and treatment of tool steel introduced by Messrs. Taylor and White, it will be advisable to examine the properties of air-hardening steels in general. The principal air-hardening steel heretofore in use is that known as "Mushet" steel. With this steel instructions are given by the makers that the tool must not be heated above cherry red, or it will be burnt, and so ruined. In the course of a series of scientific investigations to remove the question of the behavior of air-hardening steels from an empirical to a scientific basis, it was discovered that while it was true that the so-called breaking-down point of some self-hardening steels was at about a cherry red heat, yet some chemical compositions pass rapidly through this condition to one where a much higher breaking-down point is reached. The breaking-down point, then, varies for steels of various compositions, and it is possible to make an air-hardening steel which shall be heated to above 1,900° F. for the air tempering.

"The composition found to give the best results consists of an air-hardening steel containing at least ½ of 1 per cent. chromium and 1 per cent. or more of another member of the same group, tungsten being found to give the best results. Much better results are obtained, however, by using about 1 per cent. of chromium and about 4 per cent. of tungsten; while for very hard metals, such as the chilled scale on cast iron, etc., 3 per cent. of chromium and 6 or more per cent. of tungsten are especially good. It may be interesting to note that the variation in carbon seems to matter but little, steel varying from 85 to 200 points giving equally good results.

"The method of cooling the tools from the 'high heat' (about 2,000° F.) plays a very important part in the process. Although there are many ways of cooling, each one being adapted to certain classes of tools, they may be described generally as follows: The tool is cooled rapidly from the 'high heat' to a point below the breaking-down temperature in a lead bath, and then slowly in the air, or lime, etc., as the case may be. It is very essential that at no time the temperature should rise, as in such a case the tool would be seriously impaired. After the steel has cooled off, its efficiency is found to be further increased by subjecting it to what is termed the 'low heat' for about ten minutes; this temperature ranging from 700° F. to 1,240 F. After cooling from the 'low heat' the tool is ready for use. In order to obtain the best cutting edge, at least 1-16 inch should be ground off the tool, as the surface is more or less deteriorated by the high heat. The surface of special tools can be protected, however, by some form of flux, thus making it possible to treat milling cutters, etc., by this process. The treatment in all cases extends well back from the point of the tool, and permits of its being ground until so weakened as to require reforging. It is not essential to anneal the steel when reforging, and it might be well to add that all these tools can be worked with comparative ease.

"In the operation of the Taylor-White process apparatus is employed by means of which temperatures can be controlled within very narrow limits, which accounts for the uniformity of results obtained with the tools treated by this process. It has been

found necessary to modify the treatment of the special steel used in this process in order to obtain the best results under different conditions, such as varying kinds of metal cut on different types of machines, such as lathes, planers, slotters, drill presses, etc., so that no less than ten different modifications of the treatment are used in the preparation of tools for a large and fully equipped shop working on different kinds of metals and with various classes of tools. The variations required, however, in the treatment are of the most simple and easy application after once being understood, and can be handled with the full degree of success by an ordinary trained laborer.

Mr. Day gives a number of interesting experiences with this steel at the works with which he is connected, the Link-Belt Machinery Company, showing the enormous gain in time and output by the use of a steel capable of such heavy service. Thus the time of boring out a cast-iron ring on a 7-foot boring mill was reduced from fourteen hours to three and one-half hours. The machining of thirteen sheaves with the old tools required nine and one-half hours, while sixteen sheaves were finished with the new steel in five hours and five minutes. Similar results were attained in the machining of steel, the gain reaching and exceeding 60 per cent.

The possession of a tool steel which is capable of being operated at such rates involves a complete change in shop methods to enable the proper results to be attained, and workmen cannot be depended to speed up their tools to the limit practicable without some especial supervision. This is greatly aided by the fact that the steel chips produced by the new steel should be of a blue color when the tool is working dry and at the proper speed. It is therefore only necessary to turn off the water for a moment to see if the tool is working to its highest efficiency.

The necessity for operating machine tools with the new steel at higher speeds than had been originally contemplated by the builders showed the existing speed changes to be inadequate, and hence the introduction of independent electric motors has followed. In this way each tool can be operated at the best speed permissible, regardless of the other tools in the shop, and a flexibility attained which adds still more to the output.

There is every probability that the general introduction of the new steel will extend the policy of scrapping many existing machines simply because they are unequal to the speeds and stresses permitted by the tools to be used in them. The result will be what may be called production to the tool limit, the latest form of intensified production, and one which is altogether desirable because the intensification is that exerted by tools and machines, and involves no additional labor on the part of the men.

Such a system has an undoubted influence upon the labor question, and Mr. Day expresses in a few words the importance of this side of the question.

"The engineer of the present day has before him a tremendous field, the production of the best for the least money, involving a thorough knowledge of every branch of engineering, shop management, etc. The laboring man cannot stop the advance any more than he could in the past, but as he is just as much a part of the whole, as the machine or tool steel, he should be just as carefully watched, his welfare attended to, his physical and mental conditions looked after, and, in fact, be made just as good a workman as possible. In many establishments the machinery is most carefully attended to, while the man who operates it, the keynote of the whole scheme, is ignored. The importance of this fact is now being realized by many concerns, much money being spent, money which will pay big interest, to add to the comforts and welfare of the employees. It should be clearly understood that nothing is offered in the way of a bribe or obligation, the effort being to make the surroundings such that the workmen are both physically and mentally stronger, and in a position to turn out more work unconscious to themselves. Methods like these will, I think, help the labor troubles considerably and facilitate the introduction of new ideas."

The Nernst Lamp in America.

Among the papers presented at the Buffalo meeting of the American Institute of Electrical Engineers, one of the most interesting was that of Mr. A. J. Wurts, describing the Nernst lamp as made in America, together with details of the experimental

work which has been conducted upon it by himself and his associates at the works of the Westinghouse company at Pittsburg.

Although the Nernst lamp has been the subject of much discussion and interest for more than three years, it has until recently been very difficult to obtain any definite information about the details of its construction, and at the Paris exposition the lamps exhibited were most jealously protected against investigation or inspection. Mr. Wurts's paper, on the contrary, gives illustrations of all the details, and being published in the *Transactions* of the Institute, is readily accessible, while a large number of the lamps are in constant service at the Buffalo exposition.

The original invention of Dr. Nernst, of Göttingen, already noticed in these columns, consisted in using as an incandescent material a pencil of refractory earths, this being a non-conductor when cold, but permitting the passage of the electric current after it becomes heated. The advantage of such an arrangement is that it does away with the necessity of enclosing the incandescent body in an exhausted bulb as is the case with the carbon filament, while also avoiding the necessity of constant renewal, as with arc-light carbons. At the same time the system permits the construction of lamps intermediate in capacity between the arc and incandescent systems, besides yielding a higher electrical efficiency than the latter.

In the original Nernst lamp it was necessary to heat the incandescent pencil by an alcohol lamp or a match until it was made a sufficiently good conductor to permit the passage of the current, after which the resistance kept it sufficiently hot to maintain the conductivity. It was in this crude condition that the Westinghouse company took the invention, and added the improvements which are described by Mr. Wurts.

The first improvement was the method of attaching the connecting wires to the incandescent pencil, or "glower," as it has been named. The glower is about 25 millimetres long and 0.63 millimetres in diameter, and is formed from a dough of rare earths, expressed through a die and cut off in lengths, dried, and roasted. The original lamp had the connections made to this by winding platinum wire around each end. The shrinkage of the glower ends soon made the connection imperfect, but this has been remedied in the American lamp by making the connection to a platinum bead imbedded in each end. By this construction the shrinkage of the glower only tightens the connection. The next improvement made in the American lamps is the introduction of a steadying resistance, or "ballast," to enable the lamp to be operated at the best efficiency. This ballast consists of a resistance of iron wire mounted in a small glass tube filled with some inert gas, this giving a minimum resistance under normal conditions, with a rapidly increasing resistance with increasing temperature. With a 10 per cent. increase of current the resistance of the ballast increases 150 per cent., so that a glower thus protected becomes at once operative throughout a wide range.

In order that the lamp should be commercially satisfactory it was necessary that some automatic method be devised for heating the glower to a point of conductivity. Attempts at electric heaters had been made in Germany, but the problem was attacked from the start in America. It is necessary to heat the glower to a temperature of about 950° C., and hence the heater and its cut-out must be so constructed as to stand high temperatures. The heater consists of a thin porcelain tube overwound with a fine platinum wire pasted with cement, the latter serving as a protection to the platinum wire for the intense heat of the glower. The tubes are wound for 110 volts and are connected in pairs of two in series according to the service, the one, two, and three-glower lamps taking one pair, and the six-glower two pairs. Automatic cut-outs throw the heaters out of circuit as soon as the current is established through the glower, so that the lamp is lighted automatically in about 30 seconds.

Lamps have been made upon the above designs from 50 to 2,000 candle power, and from the exhibits at Buffalo and the experimental tests at Pittsburg, the problem of converting the original Nernst lamp into a commercially available system of illumination appears to have been completely solved.

So far as efficiency goes, it appears that the Nernst lamp lies about midway between the open and the enclosed arc. Compari-

sons between the Nernst and incandescent lamp indicate a watt consumption in the Nernst lamp of little less than half of that in the incandescent lamp for equal illumination.

The quality of the light is remarkable for its beauty and close approximation to daylight. All colors are seen in their proper shade, making the light especially desirable in stores, art galleries, drawing rooms and the like. The absence of shadow, the simplicity and low cost of maintenance, the high efficiency of the lamp, and the fact that it is operative on 3,000 alternations, are features that will commend themselves strongly to the lighting world.

The Selection of a Steam Boiler.

In the development of a steam plant the boilers, as the originating portion of the power, form a most important division of the whole, and rightly their selection and installation should be given corresponding care. A paper presented before the Engineer's Society of Western Pennsylvania, by Mr. W. E. Snyder, and published in the *Proceedings* of the society discusses this important question at length, and from this communication we make some abstracts.

After emphasizing the necessity for the exercise of proper engineering skill in the inspection of the boiler to be chosen, and condemning the too common practice of leaving the details of its construction entirely to the maker, Mr. Snyder enumerates five points for special investigation, namely:

1. Safety,
2. Convenience of manipulation,
3. Steaming properties,
4. Durability,
5. Cost.

The order in which these are placed is in itself significant. In nearly every case the skilled engineer, who may design boilers, but does not have to live with them, considers first the evaporative efficiency, and tries to design a boiler which will make the most steam with the least fuel. At the same time any man who knows the enormous magnitude of the stored energy in a working steam boiler will fully agree with the propriety of placing safety before everything else.

Mr. Snyder discusses at some length the question of boiler inspection, properly condemning official inspection when it is so mixed up in politics as to permit the appointment of unfit inspectors for political influence; and, while approving of efficient inspection whether official or by insurance companies, he shows the importance of such inspection during the course of manufacture as shall insure the largest margin of original safety. The employment of the best material, with actual testing of portions which go into the boiler, together with the verification of the nominal thickness of sheets, are all urged as matters too often neglected.

In regard to convenience of manipulation, this is properly placed second because continued efficiency depends upon convenience. No matter how good the design of a boiler so far as generating steam is concerned, if it is not capable of being completely and readily cleaned and kept in repair, its efficiency as a steam generator will soon be reduced to that of an inferior boiler. A boiler can best be kept clean inside by putting nothing but pure water into it; and in nearly all cases this costs less than it does to put the impurities in with the water and then take them out in the form of scale, to say nothing of the effect upon the boiler. When possible, a boiler should be so arranged that it can be cleaned, or have tubes renewed without requiring the workmen to go inside of the setting. While it is correct to say that a boiler should become entirely cold before any cleaning or repairing is done, yet at the same time the delay of a few hours in a shut down plant may mean much money, and modern intensified methods demand that quick repairs should be possible when necessary.

Safety and convenience having been provided for as far as practicable, the efficiency in steam generation should be considered.

This brings up at once the mooted question as to the rating of a boiler by the heating surface, and all the disputed points as to the relative efficiency of different kinds of heating surface. When a boiler is completed it is not a difficult matter to ascertain by test what its performance really is, although when the test is not made by a competent person the results may be far from being reliable, especially as regards the use of such a test for a guide in the

selection of a similar boiler for another purpose. As a matter of fact the mere question of heating surface is not sufficient to determine the proper rating of a boiler, as one with a low surface rating can be forced to its rated evaporative capacity only by diminishing its economy.

Mr. Snyder discusses the various questions of circulation of gases without and water within a boiler, and also calls attention to the importance of including the quality of steam in the performance of a boiler, and gives a number of practical comments which should assist in selecting a steam generator which should have not only a good test capacity and economy, but should also give good results in continuous daily work.

Durability is a topic upon which little can be said which is not included in the previous qualities. For a well constructed boiler the durability depends more than anything else upon the way in which it is treated. A boiler which is carefully fired, fed with water free from scale or grease, and is not forced far beyond its normal capacity should have a long life. Properly cared for, the working life of a boiler, like nearly every other piece of machinery, should exceed its economical life. That is, it should be found economical to scrap it and replace it with an improved design before it is actually worn out. The depreciation charge against a boiler should therefore be based upon its probable economic life, rather than on its durability, since if it is properly cared for it should certainly last as long as it is advantageous to use it.

The preceding considerations all unite to determine the last item, the cost. A cheap boiler is almost certain to prove expensive in the end, but in paying a good price for a boiler, one should be sure that he is getting what he is paying for.

The time to do the hardest and most efficient work on a boiler plant is in the selection of the boiler, and in the general planning of the details of the plant at that time. If the management of firms making new installations could only be brought to appreciate this thoroughly, it would mean a great saving of money to them, as well as an immense saving of worry and of very hard, unsatisfactory work to their operating forces in coming years.

The Indexing of Engineering Records.

THERE is a general tendency at the present time to consider seriously the importance of avoiding useless repetition of work. People have begun to learn that it does not pay to spend hours of time searching for drawings or hunting for references again and again, when, by a proper system of indexing and arranging, the work may be done in many cases once for all.

In the Engineering Index, it has been sought to arrange and classify all the important articles in the current technical press in such a manner as to render it easy to see what has been published and where to look for it. That some such system is necessary for the proper record of engineering documents in individual offices, is shown by the article by Mr. R. C. Vial upon the indexing of railway maps and drawings, published in a recent issue of *Engineering News*.

"In many railway drafting rooms little attention is paid to an economical system of indexing and filing of records, usually through lack of time for such work. A good index system in connection with an office means a saving of time and energy. Time spent in looking for a drawing or record, due to lack of system, is lost time. A man at $200 a month spending half a day with several assistants looking for some record which, under different circumstances, might be had in a few minutes, does not tend toward low operating expenses, nor the high efficiency of the office."

Mr. Vial describes the system devised for use in the drafting room of the Chicago and Western Indiana R. R., and while in its details it may need modification for other offices, yet in principle it is doubtless sound and convenient.

The general basis of the system is the decimal index, well known in library and similar work, and well applicable to the classification of records. The decimal outline given by Mr. Vial, for which the reader must be referred to the original paper, provides for the main divisions under the even hundreds from 100 to 900, while these are subdivided by tens into their general subclassifications.

At the time of the introduction of the system the drawings were kept in various places, but under the new plan all the plans were transferred to the drafting room, while

the reference record is kept entirely upon a classified card index, with guide cards and cross references, in the same manner as is used so extensively for libraries and cost-keeping systems. The convenience and elasticity of the card index renders it especially adaptable to such a changing line of subjects as forms the record material of a drafting office.

Aside from its use in indexing drawings, the card system is used for the tabulation of various data pertaining to the road in the road-master's office. These cards form an index by themselves, and are arranged by station number on each division of the road. Not only is the information thus collected in the most satisfactory form for reference, but the time required in tabulating and arranging in shape is reduced to a minimum. The card index is extended to include an index of the industries along the line, and its uses have developed to such an extent that its capacity has been increased from 4,000 to 10,000 cards.

Mr. Vial describes at length the method of indorsing and filing drawings, but this necessarily differs for various offices and must be modified for each especial case. The main thing is that there should be a system and that it should be so flexible and convenient for record and use as to be always available.

There is plenty of necessary work to be done to render it most important that no time should be wasted in uncertainties, or in looking in many places for what should be immediately available. System and order in records of all sorts have become so essential to success that the only question is that of the most suitable arrangement for the case in hand, and it is by just such descriptive papers as this of which we have spoken that one may benefit by the experience of others.

Long-Distance Transmission Lines.

WITH the introduction of electricity as a means of the transmission of energy from natural sources to points at a distance, many important problems arise which demand care and experience for their solution. For this reason the paper of Mr. F. A. C. Perrine, presented at the Buffalo meeting of the American Institute of Electrical Engineers upon the elements of design particularly pertaining to long-distance transmission, and published in the *Transactions* of the institute, is interesting and important.

Mr. Perrine calls attention to the fact that a large undertaking often differs from a smaller one in more points than merely that of size. Elements which in the smaller problem are of controlling importance do not increase with the increasing magnitude of the whole, while some minor features assume much importance, so that the whole subject has to be worked out anew and handled on its own basis.

"The electrical transmission problem is no exception to this general rule, for, were it always necessary to consider all the phenomena involved in every transmission problem, the solution of a great long-distance problem would be the same as that of the smallest piece of work, since the introduction of larger figures in an equation introduces no difficulties in the solution. But this is not the case. In short distance work there are less terms in the equation than there are in long-distance work, and in handling extremely high potentials we must consider not only the electrical factors of safety, but also mechanical factors of safety, for the reason that good insulations are never materials of great strength and can be relied upon for their mechanical properties only when the mechanical strains are unimportant in comparison with the size of the insulating pieces employed. Were it not for these considerations it might be more expensive to transmit 10,000 k. w. one hundred miles than to transmit the same amount of power a single mile, but to the competent electrician not more difficult. All of the phenomena which must be considered in short distance work are introduced into long-distance problems in the same form. The difficulty in long-distance transmission problems lies in the introduction of phenomena which are not new, but which, as has already been said, are important only in work of the latter class."

Taking up the various questions which arise, Mr. Perrine considers regulation, and shows that it is affected by capacity, mutual induction, and self-induction. With short lines, capacity is the least important of these phenomena, but with long distance lines it becomes the predominant factor. In a line of 100 miles in length, operating at a volt-

age of 50 to 60,000 volts and a periodicity of 50, the charging current amounts to something in excess of 2,000 kilovolt amperes, and employs such a proportion of the capacity at the station for charging the idle lines as to make the introduction of units smaller than 2,000 k. w. inadvisable, and renders commercially impracticable the transmission of powers less than about 3,000 k. w., unless the capacity effect be neutralized by the use of reactive coils.

Mutual induction can readily be eliminated by transposition, but self-inductive effects, while important, and increased by the length of the lines, are nevertheless comparatively small in reference to the total amount of power transmitted.

"The highest possible potentials are necessary in order to restrict the investment in very long transmission lines. When the voltages rise above 30,000 volts, phenomena become important in the problem of insulation which below that voltage were unnecessary to consider. In the first place voltages from 25,000 to 30,000 volts can be readily handled with insulators of either glass or porcelain having a diameter not exceeding 7 inches. Pieces of glass or porcelain of these dimensions are mechanically strong and are readily manufactured. Where the voltage rises to 50,000 to 60,000 volts, and the sparking distance between the lines increases to between five and six inches, the insulators must have a diameter of at least 12 or 13 inches and be held not less than 7 or 8 inches above the cross arm. Such pieces of these fragile insulating materials are difficult to manufacture, and though the problem has been successfully solved, the greatest care in design and manufacture is absolutely essential, though it is believed that the factor of safety of high-potential insulators as at present designed is by no means as great as that commonly employed with the lower voltages. An even more striking difficulty in handling high voltages lies in the effect of the electrical surface tension, which with high voltages and small wires results in a brush discharge and high energy loss independent of leakage over the surface of the insulators, being simply an escape to surrounding bodies from the whole surface of the wire."

The whole subject of long distance electrical transmission of power forms an engineering problem which from its very bigness, is one requiring the most careful solution at every step, and the fact that it is being now successfully carried out merits the highest praise both toward engineers who undertake the designing and the investors whose faith in their engineers permits the employment of the necessary capital to do the work thoroughly.

Steel Dam Construction.

THE construction of dams is a problem in civil engineering which has received an immense amount of attention, but until recently all the study has been given to timber and masonry dams. The advent of steel and concrete construction, however, has opened up a new system of design, and already this has been employed in situations where the older methods would have been difficult or expensive.

In a recent issue of *Engineering News* is given an account of the new steel and concrete dam at Redridge, Michigan, across the Salmon Trout river, the dam being intended to furnish water to the stamp mills of the neighboring copper mines.

"The Redridge dam is unique in being a gravity dam of combined concrete and steel construction, and in fact it is the first of its kind. Upon the concrete base is a steel superstructure consisting of a series of bents or A-frames carrying steel face-plates, and in this respect the dam is similar to the steel dam built for the Atchison, Topeka & Santa Fe Ry., at Ash Fork, Ariz. The most important difference in the design of the two dams lies in the use of a concrete base in the Redridge dam. In the Ash Fork dam, concrete is used merely to effect a watertight joint at the heel, the steel structure being anchored directly to the rock in a canyon, and relying upon its anchorage to resist overturning or sliding. In the Redridge dam, however, the natural formation was not favorable to such a construction, and it was decided to use a concrete base of such dimensions as to constitute a gravity dam. To this base the steel structure is anchored. The proportions are such that at any section of the dam the resultant of all pressures (when the water is level with the crest of the dam) falls within the middle third of the concrete base. The calculations were made to include sufficient friction to provide

against sliding (coefficient of friction, 0.69), but there is a large additional margin of safety against sliding movement through the fact that the concrete base is built in a trench 2 to 4 feet deep in the rock.

"The dam is 1,006 ft. long and the length of the steel portion is 464 ft. between the abutments. The maximum height is 74 ft. At either end of the steel dam are earth embankments with masonry core walls, bringing the total length of the dam to the figure above stated.

Electric Towers.

UNDER the suggestive title "From Christmas Tree to Pan-American" Mr. Luther Stieringer writes in the *Electrical World and Engineer* of the history of electrically illuminated towers up to the Pan-American exposition. A large portion of the article is purely historical, extending from the first electrical illumination, by Mr. E. H. Johnson, of a Christmas tree for his children in 1882, to the conception and execution of the marvellous lighting effects which have been the delight and admiration of all who have visited the Buffalo exposition.

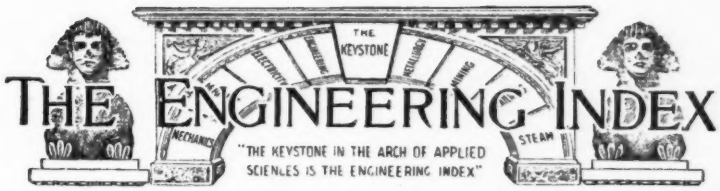
The earlier towers, shown at various exhibitions from that of the Franklin Institute in 1884 down to the Paris exposition of 1889, were mainly pillars covered with great numbers of incandescent electric lamps, which, by the manipulation of switches and keyboards could be made to exhibit rapidly succeeding changes, many of these being very effective when skilfully handled.

At the Paris exposition of 1889 the Eiffel tower presented a great opportunity which was not altogether utilized at that time, although the graceful outlines of the tower, when marked out in points of light against the dark sky formed a most effective picture. On special occasions, however, the electric effects were mingled with those of fireworks and colored fires, so that this exhibition was only partially electrical. At the Paris exposition of 1900 the tower was much improved in color, and the electrical effect was also much finer and more complete.

The electric tower at the Buffalo exposition is architecturally a more or less faithful copy of the tower of the Giralda at Seville, but in its light treatment it is far finer than anything which has preceded it. Naturally much of the architectural design is lost when it is illuminated at night, and Mr. Stieringer comments with some sarcasm upon the mistaken ideas concerning its appearance before the actual effect was seen. Instead of standing out as a mass of light against the sky, an effect which could only have been produced by throwing the light upon the tower from some outside source, the light is emitted from within in such a manner as to convert it into a special structure, with a beauty entirely its own.

Mr. Stieringer makes some excellent remarks about the proper employment of lighting effects, showing how necessary it is that these should be studied and arranged according to their own principles.

"Lighting is not a matter strictly for architects, but a special art, and the subject of special investigation for those who have to deal in addition with the complex problem of installation. No matter what beauty the architecture may possess, if a funereal aspect is to be presented on occasion, the mourning colors of a country must be chosen to drape the structures, be that white, yellow or black. If the occasion be festive in daylight, bunting in the skilled hands of the decorator will attain a festive transformation. A festive scene at night can only be effected by the aid of illumination and in no way can it be construed as incorporated in the architecture, but it is rather associated with it, and when removed it leaves no evidence of its prior existence. Had it been possible to have treated the illumination of this tower from the inside by translucency to secure a luminous effect, it would have resulted in showing up its grim steel skelton like an ugly radiograph or X-ray picture. A translucent and luminous appearance is produced in an entirely different way from all preconceived notions of the uninitiated. This effect was attained by placing lights so as to secure a nearly uniform illumination over its surface with all desirable points accentuated, producing an effect of brilliancy. The great height and size of this tower and the increased amount of light apportioned to this central section would have made it effective in a popular sense with almost any treatment."



The following pages form an index to the contents of nearly two hundred of the leading engineering journals of the world, in English, French, German, Dutch, Italian and Spanish, together with the published transactions of important engineering societies in the principal countries. It will be observed that each index item gives the following essential information about every article.

(1) The full title, (2) The name of its author,
(3) A descriptive abstract, (4) Its length in words,
(5) When published. (6) Where published.
We supply the article itself, if desired.

The Index is conveniently classified into the larger divisions of engineering science, to the end that the busy engineer and works manager may quickly turn to what concerns himself and his special branches of work. Thus this Index makes it possible within a few minutes' time each month to inform one's self of every important article published anywhere in the world upon the subjects claiming one's special interest.

The original of any article referred to in the Index, together with all illustrations, can be supplied by us. See the "Explanatory Note" at the end, where also the full titles of the journals indexed are given.

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CIVIL ENGINEERING

BRIDGES.

Alteration.

Whether to Strengthen the Old Bridge or Renew It? H. G. Tyrrell. Discusses when it is impracticable to make over old bridges; method of estimating, etc. 1000 w. R R Gaz—Aug. 2, 1901. No. 42507.

Arches.

Arch Centers. James W. Rollins, Jr. An illustrated discussion of methods of construction, and design, considering especially the structures described in Mr. Cheever's paper. 1500 w. Jour Assn Engng Socs—July, 1901. No. 42675 C.

We supply copies of these articles. See page 159.

Brooklyn Bridge.

Broken Suspension Rods on Brooklyn Bridge. Statement of the accident with report of C. C. Martin, and opinions of Washington A. Roebling. Ill. 2300 w. R R Gaz—Aug. 2, 1901. No. 42510.

The Accident to the Brooklyn Bridge. A letter from Wilhelm Hildenbrand in explanation of the recent accident and of the strength and construction of the bridge. Also short letters from Gus. C. Henning and J. Calvin Locke. 4000 w. Eng News—Aug. 8, 1901. No. 42604.

The Accident to the Brooklyn Bridge. Editorial discussion of the cause of the breaking of suspender rods at the center of the northernmost main cable, on July 24, with Mr. Martin's report, and comments. Ill. 2000 w. Eng News—Aug. 1, 1901. No. 42482.

The Brooklyn Bridge Accident. An illustrated account of the cause of traffic being suspended on July 24, with explanation of C. C. Martin, the chief engineer. 1400 w. Ir Age—Aug. 1, 1901. No. 42456.

The Failure of the Brooklyn Bridge. A discussion of the cause of the accident, with editorial comment. Ill. 2500 w. Sci Am—Aug. 3, 1901. No. 42476.

The Safety of the Brooklyn Bridge. An editorial discussion of the recent failures of suspension rods, recommending an effective system of inspection. 1000 w. Eng Rec—Aug. 17, 1901. No. 42756.

Cleveland, O.

New Overhead Bridge, Willett Street, Cleveland, O. D. M. Taylor. Side elevation line engraving, with photograph and brief description. 800 w. Ry & Engng Rev—Aug. 3, 1901. No. 42556.

Concrete.

Hinged Concrete Bridge at Las Segadas (Pont en Béton de Las Segadas, à Articulations). I. E. Ribera. Illustrated description of concrete arch of 50 meters span, with metal joints at crown and springings, over the Nalon Valley, in the Province of Oviedo, Spain. Two articles. 3500 w. Revue Technique—July 10, Aug. 10, 1901. No. 42812 each D.

East River, N. Y.

East River Bridge, No. 4. Henry A. La Chicotte. Illustrated description of this fourth bridge to be constructed across the East River at New York, with remarks on the residence district it will make accessible. 1400 w. R R Gaz—Aug. 16, 1901. No. 42678.

The Three Great Suspension Bridges Across the East River, New York. Illustrations and brief notes concerning the bridges completed, in process of construction, and planned. 1200 w. Sci Am—Aug. 3, 1901. No. 42475.

Failure.

Collapse of the Foot-Bridge at the Paris Exhibition. Information from the report of the experts appointed to investigate this accident. 1200 w. Engr, Lond—Aug. 16, 1901. No. 42952 A.

The Fall of a Portable Bridge by Buckling (Chute par Gauchissement d'un Pont Démontable). M. S. Périssé. A discussion of the failure of the bridge over the Adour in 1897, with calculations of the strength and weakness of the girders. 6000 w. 1 plate. Mem Ser Ing Civ de France—June, 1901. No. 42815 G.

North Wales.

Tal-y-Cafn Bridge, North Wales. Description with illustrated details of a bridge built on a site of an ancient ferry. It consists of a steel superstructure supported on limestone masonry abutments, with concrete backing at the shore ends. 800 w. Engng—Aug. 2, 1901. No. 42644 A.

Ornamental.

Ornamental Bridges. H. G. Tyrrell. An illustrated article discussing a few examples of high-class bridge design and construction. 3 two-page plates. 1600 w. Am Arch't—Aug. 24, 1901. No. 42774.

Piers.

Rebuilding Pier No. 4 of the Aqueduct Bridge, Georgetown, D. C. Illustrated description of difficult caisson work in 28 ft. of water, involving the support of the adjoining ends of two spans of a highway bridge on temporary towers while the old pier was torn down and rebuilt. 3100 w. Eng Rec—Aug. 10, 1901. No. 42615.

Reinforced Concrete.

Concrete-Steel Bridges in Porto Rico. Edward Thacher. An illustrated detailed description of two bridges built by the writer, with account of tests of the structures and materials, the difficulties encountered, etc. 5000 w. Eng News—Aug. 1, 1901. No. 42479.

See Civil Engineering, Construction.

Rhine.

New Bridge Over the Rhine. Drawings and description of the bridge at Worms, with information of the extent and character of the design. 3000 w. Engr, Lond—July 26, 1901. No. 42529 A.

Riveting.

Bridge Riveting in India. J. Graham. Information concerning the work and workmen, wages, etc. Ill. 2200 w. Engr, Lond—Aug. 9, 1901. No. 42734 A.

Stone Arch.

Stone Arch Bridges Recently Constructed on the Fitchburg Railroad. Albert S. Cheever. Illustrated descriptions and accounts of the construction of five bridges recently built on the railroad named. 4 plates. 2200 w. Jour Assn of Engng Socs—July, 1901. No. 42674 C.

We supply copies of these articles. See page 159.

Suspension Truss.

The Peissnitz Bridge at Halle-on-the-Saale (Die Peissnitz-Brücke in Halle a. S.). M. Ziegler. Illustrated description of the handsome suspension truss bridge of 70 metres span over the Saale at Halle. 3000 w. Zeitschr d Ver Deutscher Ing—Aug. 17, 1901. No. 42835 D.

Swing Bridge.

Aber Swing Bridge, Carnarvon. Illustrated detailed description of the bridge over the river Seiont. 900 w. Engr, Lond—Aug. 2, 1901. No. 42651 A.

Riveted Lattice Truss Drawbridge; Chicago & Northwestern Ry. Illustrated detailed description of a swing bridge near Milwaukee, with trusses of the type named. 4300 w. Eng News—Aug. 8, 1901. No. 42602.

Viaduct.

Boone Cut-Off and Des Moines River Viaduct; Chicago & Northwestern Ry. Illustrates and describes details of this structure on the new short line. 1800 w. Eng News—Aug. 22, 1901. No. 42906.

The Boone Viaduct. Illustrates and describes some of the details of the steel-work and its erection. 1500 w. Eng Rec—Aug. 24, 1901. No. 42917.

The Erection of the Gokteik Bridge. Day Allen Willey. Illustrated description of this structure in Burma, Asia, which is notable for its height, length, and the remarkably short time in which it was built. 1200 w. Sci Am—Aug. 17, 1901. No. 42668.

The New Riverside Viaduct, New York. Brief illustrated description of the fine viaduct connecting Riverside Drive with the northerly end of Manhattan Island. 800 w. Sci Am—Aug. 3, 1901. No. 42474.

CANALS, RIVERS AND HARBORS.

Cranes.

80-Ton Floating Crane. Two-page plate and engraving of a crane intended for the Santos Harbor Works, with brief description. 400 w. Engng—Aug. 9, 1901. No. 42733 A.

Dam.

The Redridge Dam. An illustrated detailed description of a gravity dam of combined concrete and steel construction, built in the copper region of Michigan, to furnish water to the stamp mills. 3200 w. Eng News—Aug. 15, 1901. No. 42687.

Docks.

Barrow Docks and Approaches by Land and Sea. Frank Stileman. Describes these docks, owned by the Furness Railway Company. Illustrated by 5 plates and 3 figures. 2400 w. Inst Mech Engrs—Aug., 1901. No. 42592 D.

Ore Docks with Metal Piling. Brief illustrated description of one of the ore docks of the Cleveland, Lorain & Wheeling Ry., in which metal pipes are used in its construction; the piles of part of the dock are of wrought-iron pipe, while for the rest of the length they are of steel I-beams. 700 w. Eng News—Aug. 22, 1901. No. 42907.

Feed Gates.

The Electric Feed Gates at Münster and Gleesen (Die Elektrisch Betriebewen Sparschleusen bei Münster und Gleesen). H. Rudolph. A description of the apparatus for regulating the supply of feed water to the upper section of the Dortmund-Ems Canal. Serial, Part I. 3500 w. Zeitschr d Ver Deutscher Ing—July 20, 1901. No. 42822 D.

Lighthouses.

Modern Lighthouses (Les Phares Actuels). G. Leugny. A review of modern illuminating devices for lighthouses, with especial reference to those of France. 2000 w. Revue Technique—July 10, 1901. No. 42813 D.

Mexico.

The Drainage of the Valley of Mexico. Illustrated paper by John B. Body before the Inst. of Civ. Engrs., describing the method of excavating a 29½ mile canal by hand labor, ladder dredges and a cableway. 3600 w. Eng Rec—Aug. 10, 1901. No. 42618.

Mississippi.

The Increasing Elevation of Floods in the Lower Mississippi River. Linus W. Brown. Gives statistics and facts concerning these floods and an outline of the author's views of the cause producing the conditions, and the remedy. Also discussion. 2100 w. Jour Assn Engng Socs—June, 1901. No. 42594 C.

Moldau-Elbe.

The Status of the Canalisation of the Moldau and Elbe at the Close of 1900 (Ueber den Stand der Canalisierungsarbeiten an der Moldau und Elbe am Schlusse des Jahres 1900). J. Riedel. With data of progress and cost, and diagrams of the capacity of locks. 1000 w. Zeitschr d Oesterr Ing u Arch Ver—July 26, 1901. No. 42829 B.

River Sanitation.

The State Sanitary Survey of the Illinois and Desplaines Rivers. A report of the investigations and the conclusions reached by Dr. John H. Long. 3000 w. Eng Rec—Aug. 17, 1901. No. 42757.

Silt-Bearing Streams.

Effects of Dams and Like Obstructions in Silt-Bearing Streams. Elmo G. Harris. A study of the changes due to a deposit of silt, with conclusions reached. 1400 w. Eng News—Aug. 15, 1901. No. 42693.

We supply copies of these articles. See page 159.

CONSTRUCTION.

Armory.

The Thirteenth Regiment Armory, Scranton, Pa. Floor plans and details of roof trusses are given with description. 3200 w. Eng Rec—Aug. 24, 1901. No. 42921.

Concrete Floors.

Concrete-Steel Foundry and Power Station Floors. Illustrated detailed description of floors in a machine shop and foundry at Paterson, N. J. 1400 w. Eng Rec—Aug. 17, 1901. No. 42759.

Elevators.

Elevator Construction. John Kennedy. Report of an inspection made of fire-proof grain elevators. 2800 w. Can Engr—Aug., 1901. No. 42568.

Modern Grain Elevators. Illustrated descriptions of two of the latest elevators erected in Minneapolis. 700 w. Sci Am—Aug. 24, 1901. No. 42771.

Excavating.

Steam Excavating and Grading Machine. Illustrated description of a grading machine attached to a traction engine, and its operation. 1100 w. Eng News—Aug. 15, 1901. No. 42684.

Fireproof Construction.

Tests of the Strength of Guastavino Floor Arches. Illustrated report by W. W. Ewing on weight tests of 6, 10, and 12-ft. arches. 1000 w. Eng Rec—Aug. 3, 1901. No. 42541.

Highways.

The Building of American Highways. George Ethelbert Walsh. Discusses the conditions which led to the movement for improved roads, what has been accomplished, the new industry developed, etc. 3800 w. Gunton's Mag—Aug., 1901. No. 42485 C.

Hospitals.

The New Children's Hospitals in Paris (Les Nouveaux Hôpitaux d'Enfants à Paris). M. Seurat. Fully illustrated descriptions of the Hospital Bretonneau and the Hospital Trousseau at Paris, with details of the technical and mechanical equipment. 5000 w. 2 plates. Génie Civil—July 27, Aug. 3, 1901. No. 42802 each D.

Loads.

Diagrams for Calculating the Safe Load on Cast-Iron Columns According to the New York Building Code. A. Samuel Berquist. Gives diagram and explanation of the method of using. It gives also the radius of gyration and sectional area and all information needed in designing cast iron columns. 1400 w. Eng News—Aug. 15, 1901. No. 42686.

Pan-American.

The Horticultural, Forestry and Graphic Arts Buildings of the Pan-American Exposition. Elevation and details, with description of methods of construction. 1800 w. Eng Rec—Aug. 24, 1901. No. 42922.

Piers.

See Civil Engineering, Bridges.

Reinforced Concrete.

Quay Walls and Retaining Walls of Concrete and Iron (Quaimauern und Futtermauern aus Beton und Eisen). A description of the use of the Hennebique system in England and in France. 1800 w. Zeitschr d Oesterr Ing u Arch Ver—Aug. 9, 1901. No. 42830 B.

See Civil Engineering, Bridges.

Steel Structures.

Effects of Splicing and Riveting. Extracts from a paper by George S. Morison describing experiments on the strength of riveted tension members, with editorial discussing the experiments and Mr. Morison's deductions. 3200 w. Eng Rec—Aug. 10, 1901. No. 42616.

Steel-Work.

The Steel-Work in Skeleton Buildings. Extracts from a lecture by W. C. Furber, discussing rust prevention, fireproofing, and the design of columns. 3300 w. Eng Rec—Aug. 3, 1901. No. 42539.

MATERIALS.

Building Stones.

Building and Monumental Stones of Colorado. Arthur Lakes. Where some of the varieties are found, describing their various qualities and appearance. Ill. 2400 w. Mines & Min—Aug., 1901. No. 42625 C.

Cement.

A Machine for Investigating the Rate and Time of Set of Cement Mortars. Edgar B. Kay. Illustrated description of a machine recently installed in the Cement Laboratory of the College of Civil Engng., Cornell Univ. for investigation uses. 800 w. Eng News—Aug. 8, 1901. No. 42608.

The Decomposition of Cement by Sea-Water. Abstract of a paper by H. Le Chatelier, presented before the International Congress, at Paris, discussing this subject. 2100 w. Eng News—Aug. 15, 1901. No. 42691.

The Omega Portland Cement Works, Jonesville, Mich. Illustrated detailed description of these works and their equipment, and the methods employed. 2700 w. Eng Rec—Aug. 17, 1901. No. 42760.

The Reaction of Sulphate of Lime on Cement (Réaction du Sulfate de Chaux sur les Ciments). M. Deval. A record of analyses and tests, showing the effect of sulphate of lime upon the setting of anhydrous and hydrated cements. 3000 w. Bull Soc d'Encour—July 31, 1901. No. 42821 G.

We supply copies of these articles. See page 150.

MUNICIPAL.

Address.

Municipal Engineering. J. M. Smail. An address before the Engng. Sec. of the Royal Soc. of N. S. W. Reviews the development of municipal engineering in Sydney, discusses its general bearing on the interests of the ratepayer, and outlines an ideal municipal government in relation to engineering. 2000 w. Aust Min Stand —July 18, 1901. Serial. 1st part. No. 42728 B.

Drainage.

The Main Drainage of Woking, England. Nicholas Maughan. Abstract of a paper published by the Inst. of Civ. Engrs. Describes the scheme of main drainage of this parish in Surrey, Eng., and the system of sewage purification. 3500 w. Eng Rec—Aug. 24, 1901. No. 42920.

Garbage Disposal.

The Unsatisfactory Condition of Garbage Disposal in the United States. M. N. Baker. Read before the League of Am. Munic., at Jamestown, N. Y. Discusses the inadequate service and primitive methods and suggests points for improvement. 1800 w. Eng News—Aug. 22, 1901. No. 42905.

Garbage Furnaces.

Proposed Garbage Furnaces with Heat Utilization at Buenos Ayres, Argentine Republic. Information concerning specifications for five plants with a combined capacity of 800 tons a day, for which this city calls for bids. 900 w. Eng News—Aug. 8, 1901. No. 42607.

Pavements.

Paving Brick and Brick Pavements. H. J. March. Excerpts from a lecture given before the Engrs.' Soc. of Western New York. 7500 w. Brick—Aug., 1901. No. 42562.

The Expansion of Brick Pavements. Describes the phenomena noticed in several cities where grout filler is used. 1000 w. Eng Rec—Aug. 10, 1901. No. 42619.

Sewage Disposal.

Bacterial Sewage Disposal in England. Extracts from a report by C. H. Rust of the result of investigations in numerous cities. 2000 w. Eng Rec—Aug. 10, 1901. No. 42617.

Preliminary Conclusions of the British Royal Commission on Sewage Disposal. The conclusions given relate to the questions of kinds of land available for sewage treatment, whether the new bacterial processes without subsequent land treatment are sufficient, and what should be done for better river protection. 800 w. Eng News —Aug. 15, 1901. No. 42694.

Sewerage and Sewage Disposal. Solon C. Smith. From a paper read before the Ohio Inst. of Min. Engrs. Discusses the modern methods and the progress of this branch of sanitary engineering. 4000 w. Munic Engng—Aug., 1901. No. 42560 C.

The Biological Purification of Sewage (De Biologische Reiniging van Afvalwater). J. van der Breggen. Description of the septic tank and oxidising beds in use at Winterswijk. 1500 w. De Ingenieur—Aug. 3, 1901. No. 42848 D.

WATER SUPPLY.

Filter.

The Kurka Stone Filter System (Stein filter, System Kurka). With illustrations showing the arrangement of filtering tubes of artificial stone to form large or small units. 1800 w. Glaser's Annalen—Aug. 15, 1901. No. 42833 D.

Reservoirs.

A Concrete Reservoir Lining at Salt Lake City, Utah. Illustrates and describes interesting features of this concrete construction. 900 w. Eng Rec—Aug. 24, 1901. No. 42919.

Open and Covered Service Reservoirs. W. Ingham. Read before the Brit. Assn. of Water-Works Engrs. Extracts from a paper dealing with the design, construction and cost of open and covered reservoirs. 4800 w. Jour Gas Lgt—July 30, 1901. No. 42582 A.

Southern California.

Noteworthy Water Storage and Irrigation Works of Southern California. Robert Fletcher. Describes several important systems and the regions watered. 4800 w. Eng News—Aug. 22. 1901. No. 42911.

Water Problem.

The Question of Water Supply in the South-west. W. C. Potter. The serious trouble about water in Southern California, Arizona, and New Mexico, and the success in overcoming the difficulties is discussed. Ill. 1200 w. Eng & Min Jour—Aug. 24, 1901. No. 42789.

Water Purification.

The Purification of Water by Iron (L'Epuration des Eaux par le Fer). A description of the practical working of the Anderson process with Seine water at Choisy-le-Roi, near Paris. Two articles. 4000 w. Révue Technique—July 10, 25, 1901. No. 42811 each D.

Water-Works.

The Appraisal of the Gloucester Water-Works. Review of a decision by the Massachusetts Supreme Court allowing a private water company, without an exclusive franchise, a large sum for its good will. 2000 w. Eng Rec—Aug. 10, 1901. No. 42613.

Water-Works for the C. R. Baird Co.'s Iron Mines at Ogden, Va. John N. Ambler. Plan and profile of the works is given, with description. The distinctive

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feature consists in the gravity main of 6-in. vitrified clay pipe which conveys the water from the summit to the mines. 1100 w. Eng News—Aug. 15, 1901. No. 42692.

MISCELLANY.

Irrigation.

Experiments on Winter Irrigation of Deciduous Orchards in Southern Arizona. Summary and conclusions of Alfred J. McClatchie, having a bearing on the design of irrigation works. 900 w. Eng News—Aug. 15, 1901. No. 42689.

National Aid to Irrigation: A Bill to Come Before the Next Congress. Also editorial. Letters from Fred. Bond and George H. Maxwell, discussing the bill. 8000 w. Eng News—Aug. 8, 1901. No. 42605.

Undermining.

The Effect of Railway Tunneling on St. Paul's Cathedral, London. Letter published in the London *Times*, written by Somers Clarke, outlining the condition of this great building. 1900 w. Eng Rec —Aug. 24, 1901. No. 42923.

INDUSTRIAL ECONOMICS

Arbitration.

Industrial Arbitration. Chauncey H. Castle. Read before the Nat. Civil Fed. Con. Gives a plan that has worked most successfully, called a method of conciliation through conference. 3200 w. Am Mach—Aug. 8, 1901. No. 42572.

British Railways.

British Railways as Affected by Higher Fuel, Material and Labor. Compares the records of the five principal railways, to show the general situation, and considers the extent, duration and its incidence. 2400 w. Ir & Coal Trds Rev—Aug. 16, 1901. No. 42949 A.

Cost Keeping.

The Proper Distribution of Establishment Charges. A. Hamilton Church. This third article discusses the scientific machine rate and the supplementary rate, and develops an accurate system. 3300 w. Engineering Magazine—Sept., 1901. No. 42893 B.

Electric Power.

Electric Power as a Factor in Industrial Prosperity. D. N. Dunlop. The present article considers the circumstances which retard the progress of electrical power and the advantages. 3200 w. Ir & Coal Trds Rev—Aug. 16, 1901. Serial. 1st part. No. 42946 A.

German Metal.

German Metal Exports and Imports in 1901. A review of statistics from the report for the first six months of the year. 1000 w. U. S. Cons Repts, No. 1122—Aug. 24. 1901. No. 42781 D.

Labor.

The Classification and Valuation of Labor. David Carnegie. Discusses the need of classification and valuation; how it should be classified; who should value it, etc.; the advantages. 2300 w. Prac Engr —Aug. 2, 1901. No. 42641 A.

Steel Strike.

A Candid View of the Steel Strike. George Gunton. The editor's opinions concerning this strike and his recommendation of a mutual union in which both capital and labor are equally represented, to determine all disputed questions. 3200 w. Gunton's Mag—Aug., 1901. No. 42484 C.

Sugar Industry.

The Development of the Indian Sugar Industry. Discusses the reasons for lack of enterprise, considering the ignorance of the best methods, and the need of better machinery to be in part the cause. 1600 w. Engr, Lond—Aug. 2, 1901. Serial. 1st part. No. 42646 A.

Sweden.

The Swedish Iron, Steel, Metal and Coal Industries in 1900. The report for the year is reviewed. 2000 w. Ir & Coal Trds Rev—Aug. 16, 1901. No. 42954 A.

Tariff.

The New Tariff Duties (Der Neue Zolltarif). The full text of the sections of the new tariff law of Germany relating to iron and steel products. 6000 w. Stahl und Eisen—Aug. 15, 1901. No. 42845 D.

Trade Unions.

The Responsibility of Trade Unions Under the Law. Remarks on the judgment of the House of Lords in the case of the Taff Vale Co. against the Amalgamated Soc. of Ry. Servants et al., adopting the principle that Trade Unions can be sued and held responsible for the acts of their officers. 2000 w. Jour Gas Lgt—July 30, 1901. No. 42576 A.

Upper Rhine.

Notes on the Industries of the Upper

We supply copies of these articles. See page 159.

Rhine. John Richards. Interesting account of the wine industry, the commerce of the river, the vessels used, machinery works, and various matters of interest. 8300 w. Jour Assn of Engng Socs—July, 1901. No. 42676 C.

Wages.

What Shall Fix Fair Wages? Editorial discussion of what is a fair wage, with the problems connected, with reference to strikes and the demands at issue. 2000 w. Eng News—Aug. 1, 1901. No. 42481.

ELECTRICAL ENGINEERING

COMMUNICATION.

Cables.

A New Method of Localizing a Fault in a Single Cable. Walter Betts. Describes a method of testing approaching the loop test in accuracy and simplicity. 1000 w. Elec Rev, Lond—Aug. 16, 1901. No. 42937 A.

On a Form of Artificial Submarine Cable. Augustus Trowbridge, in the *Physical Review*. Describes a simple piece of apparatus designed to imitate the action of a submarine cable used in teaching physics. 1300 w. Elec, N. Y. July 31, 1901. No. 42461.

Coherers.

See Electrical Engineering, Electro-Physics.

Exchange.

The New Trunk Exchange No. 1, Berlin. An account of this recently installed exchange, described by Herr Lindow in the *Electrotechnische Zeitschrift*, which is intended to deal with the whole trunk wire traffic of Berlin. 2200 w. Elec Rev, Lond—July 26, 1901. No. 42520 A.

Multiplier.

The Theory of the Multiplier for Rapid Electric Oscillations (Zur Theorie des Multiplikators für Schnelle Elektrische Schwingungen). G. Seibt. A mathematical examination of the multiplier used in space telegraphy by Professor Slaby. 5000 w. Elektrotech Zeitschr—July 18, 1901. No. 42866 B.

Signal Apparatus.

Simple Time Signal Apparatus. S. M. Kintner. Illustrated description of a simple design, installed at low cost to signal the beginning and end of lecture hours at the Western University of Pennsylvania. 1100 w. Am Elect'n—Aug., 1901. No. 42468.

Sounder.

The Morse Sounder. E. C. Barton. An examination of the proper method of proportioning the various parts of a telegraphic circuit. 2000 w. Aust. Min. Stand—July 18, 1901. Serial. 1st part. No. 42730 B.

Space Telegraphy.

Recent Progress in Spark Telegraphy (Die Neuesten Fortschritte auf dem Gebiete der Funkentelegraphie). A. Slaby. An address before the Verein deutscher Ingenieure, reviewing the work of Marconi, Slaby, Tesla, and others. 5000 w. Zeitschr d Ver Deutscher Ing—July 27, 1901. No. 42823 D.

Wireless Telegraph Experiments Between Brussels, Malines and Antwerp. Emile Guarini. An illustrated detailed account of these interesting experiments by the writer. 2300 w. Elec Wld & Engr—Aug. 3, 1901. No. 42542.

Station Signalling.

Methods of Communication in Electric Generating Stations. Considers the methods used in stations, and their value, and advises the addition of a private telephone. 2200 w. Elec Rev, Lond—Aug. 16, 1901. No. 42938 A.

Subways.

Underground Construction. D. R. Craig. The first of a series of illustrated articles dealing with this department of telephone work. 1200 w. Telephony—Aug., 1901. Serial. 1st part. No. 42765.

Telegraphy.

Clark on the Conditions of American Telegraphy. Discusses the map, chart and evidence of Thomas F. Clark, vice-president of the Western Union Telegraph Co., presented before the U. S. Industrial Commission. 1200 w. Elec Wld & Engr—Aug. 24, 1901. No. 42903.

Rapid Telegraphy. Patrick B. Delany. Discusses the causes of delays in sending messages by the Morse system, and maintains that future progress must be in high speed. 1200 w. Elec Wld & Engr—Aug. 24, 1901. No. 42902.

Telephony.

An American Review of Telephony Abroad. A review by U. N. Bethell. An abstract of evidence given before the U. S. Ind. Com., containing much matter of interest. 8700 w. Elec Wld & Engr—Aug. 3, 1901. No. 42543.

A Typical New York Telephone Central Office. Illustrated description of the Eighteenth Street office; a model installation on the common battery system. 1800 w. Elec Rev, N. Y.—Aug. 24, 1901. No. 42786.

We supply copies of these articles. See page 159.

Telephone Service in Connection with Long Distance Power Transmission. T. E. Theberath. An illustrated article relating experiences encountered in this work. 1500 w. Jour of Elec—July, 1901. No. 42798 C.

The Rochester Telephone Company's Equipment. Illustrated description of a modern plant for a city of medium size. 1600 w. Elec Rev, N. Y.—Aug. 3, 1901. No. 42555.

The Tunbridge Wells Telephone System. An illustrated account of the undertaking and the opening ceremony. 4500 w. Elec Engr, Lond—Aug. 2, 1901. No. 42642 A.

DISTRIBUTION.

Alternating Currents.

Comparison of Methods of Secondary Distribution of Alternating Currents. George C. Holberton. Read before the Pacific Coast Gas Assn. Principally a comparison of the methods of secondary distribution at 100 volts, 2-wire, 200 volts, 3-wire, and 400 volts, 3-wire. 2700 w. Am Gas Lgt Jour—Aug. 12, 1901. No. 42632.

Calculations.

Some Notes on Electric Light and Power Distribution. Daniel W. Mead. These notes are intended only to give an outline of the subject and point out the basis for calculations and estimates. Considers the electric generator. 1600 w. Munic Engng—Aug., 1901. No. 42557 C.

Frankfort-on-Main.

Electrical Distribution in Frankfort. Illustrated detailed description of this single phase, alternating high-tension system. 1600 w. Engr, Lond—Aug. 16, 1901. No. 42951 A.

Niagara.

Distribution and Conversion of Received Currents. Discussion of paper by Henry Gordon Stott. 5400 w. Trans Am Inst of Elec Engrs—June & July, 1901. No. 42747 D.

Polyphase.

A Large Polyphase Workshop Distribution Plant. Illustrated description of the plant for the New York Navy Yard. 2000 w. Elec Wld & Engr—Aug. 17, 1901. No. 42709.

Switching.

A Discussion of High Tension Switching and Fusing Practices. A discussion upon the papers presented at the convention of the Pacific Coast Elec. Trans. Assn. 7200 w. Jour of Elec—July, 1901. No. 42799 C.

High-Tension Switching and Fusing Devices. R. S. Masson. Read before the Pacific Coast Elec. Trans. Assn. An illustrated article giving some suggestions in high-tension switching. 1800 w. Jour of Elec—June, 1901. No. 42438.

The Latest General Electric Types. H. C. Wirt. Illustrates and describes oil switches and expulsion circuit breakers. 800 w. Jour of Elec—June, 1901. No. 42442.

The Latest Stanley Types. W. Currie. Illustrated descriptions of apparatus. 2000 w. Jour of Elec—June, 1901. No. 42441.

The Latest Westinghouse Types. W. M. McFarland. Illustrates and describes circuit-breakers constructed on the general principle employing the open arc and carbon break. 900 w. Jour of Elec—June, 1901. No. 42440.

The Martin High Potential Switch. F. V. T. Lee. Illustrated description of a switch designed for fulfilling the requirements of the Yuba Power Co. on its 16,500-volt line. 2000 w. Jour of Elec—June, 1901. No. 42439.

Three-Phase.

The Elements of Three-Phase Theory. Alexander Russell. Discusses fundamental theorems, giving mathematical proofs and graphical constructions. 3200 w. Elect'n, Lond—Aug. 16, 1901. No. 42942 A.

ELECTRO-CHEMISTRY.

Address.

Electro-Chemical Industry. J. W. Swan. Abstract of the presidential address delivered before the Soc. of Chem. Ind., at Glasgow, with editorial. 8200 w. Elect'n. Lond—July 26, 1901. No. 42514 A.

Accumulators.

The New Edison Storage Battery. Discussion of paper by Dr. Arthur E. Kennelly. 7500 w. Trans Am Inst of Elec Engrs—June and July, 1901. No. 42750 D.

The Pascal Marino Accumulator. W. Hibbert. Illustrated description of a lead accumulator employing phosphoric acid, with a statement of advantages claimed. 1100 w. Elec Rev, Lond—July 26, 1901. No. 42516 A.

Batteries.

The Battery. S. Lees. Concerning the care of accumulators. Ill. 1800 w. Elec Engr, Lond—Aug. 16, 1901. No. 42936 A.

Fluorine.

Moissan's Researches on Fluorine and the Fluorine Compounds. Dr. H. F. Keller. An account of the researches of this chemist in the field named. Ill. 4500 w. Jour Fr Inst—Aug., 1901. No. 42489 D.

ELECTRO-PHYSICS.

Armatures.

The Conditions of Transformation in the Continuous-Current Armature (Ueber die Transformationeigenschaften der Gleich-

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stromarmatur). F. Eichberg. An examination of the action of tne armature, with diagrams enabling the relations of the currents at any point to be determined. 1500 w. Elektrotech Zeitschr—July 11, 1901. No. 42863 B.

The Distribution of Lines of Force in Slotted Armatures (Ueber die Kraftlinienvertheilung in Nuthenankern). E. Dick. A mathematical investigation, taking into account the dimensions of the teeth and the magnitude of air-gaps. 4000 w. Elektrotech Zeitschr—July 25, 1901. No. 42869 B.

Coherers.

Coherers—The Development, Construction, Operation and Function of Electric Wave Detectors. A. Frederick Collins. An illustrated article. 2000 w. Elec Wld & Engr—Aug. 17, 1901. No. 42710.

Magnetism.

The Electromagnetic Effects of Moving Charged Spheres. Edwin P. Adams. A description of experimental investigations, with statement of results. Ill. 3300 w. Am Jour of Science—Aug., 1901. No. 42472 D.

GENERATING STATIONS.

Alternators.

The Construction and Systematic Manufacture of Alternators. O. Lasche. The first of a series of articles which will discuss the conditions underlying the construction and systematic manufacture of alternators of various types. Ill. 1900 w. Engng—Aug. 9, 1901. Serial. 1st part. No. 42731 A.

The Interpolar Induction and Distribution of Copper in the Armature of a Siemens 12-Pole Alternator. Ernest Wilson and William Marden. Describes experiments made at King's College, London, stating the objects in view and the results. Ill. 1100 w. Elect'n, Lond—Aug. 16, 1901. Serial. 1st part. No. 42941 A.

Bangor, Me.

Electrical Supply in Bangor, Maine. Alton D. Adams. Describes the system for supplying light and power. 1100 w. Elec Wld & Engr—Aug. 24, 1901. No. 42901.

Boston, Mass.

The Lincoln Power Station, Boston, Mass. An illustrated description of this new station, which is to supplement the other stations in supplying power for the Boston Elevated Ry. 4000 w. Eng Rec—Aug. 17, 1901. No. 42758.

Brooklyn, N. Y.

The Kings County Station of the Edison Illuminating Company of Brooklyn. Illustrates and describes this station as representing standard practice in high-tension generation. 1600 w. Elec Rev, N. Y.—Aug. 17, 1901. No. 42700.

Buffalo N. Y.

The New Buffalo Terminal Transformer Station of the Cataract Power and Conduit Company. Fred. P. Woodbury. Illustrated detailed description of a station representing the most advanced practice. 1300 w. Am Elect'n—Aug., 1901. No. 42465.

Generating Set.

Two Phase 750 Kilowatt Generating Set by Farcot (Groupe Electrogène à Courants Diphases de 750 Kilowatts de la Maison J. Farcot. An illustrated description of the exhibit of the house of J. Farcot at the Paris Exposition; both engine and generator being built by the one firm. 2500 w. Revue Technique—July 25, 1901. No. 42805 D.

Generators.

The Regulation of Alternating Current Generators. A. S. M'Allister. Considers the causes of change in generator e. m. f., and the advantages of two-phase and three-phase generators. Ill. 2300 w. Am Elect'n—Aug., 1901. No. 42467.

Massena, N. Y.

The Massena Power Development. Illustrated account of the progress of work on this great power plant of the St. Lawrence. 1700 w. Elec Rev, N. Y.—July 27, 1901. No. 42447.

Parallel Running.

Parallel Running of Alternators. A few points on the subject of engine design for this purpose are discussed. 800 w. Elec Rev, Lond—July 26, 1901. No. 42518 A.

The Parallel Operation of Alternators from the Engine-Builder's Point of View. W. Trinks. A discussion of all the elements entering into the successful parallel operation of direct coupled alternators, with brief general discussion. 8800 w. Pro Engs' Soc of W. Penn—May, 1901. No. 42776 D.

Specifications.

Power Plant Specifications. Cloyd Marshall. Discusses the more important elements to be decided in planning an electric transmission system. 2300 w. Engr, U. S. A.—Aug. 15, 1901. No. 42701.

Station Signalling.

See Electrical Engineering, Communication.

Storage Batteries.

Storage Batteries in Central Stations. R. F. Schuchardt. An account of an accident in the Harrison St. station of the Chicago Edison Co., giving load curves showing how the load was dropped by section No. 1, and picked up by section No. 5 and the batteries, and pressure charts showing how quickly the changes were made. 500 w. Elec Wld & Engr—Aug. 17, 1901. No. 42711.

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Works.

Hoylake and West Kirby Electricity Works. Illustrates and describes details of the plant and equipment. 1500 w. Elec Engr, Lond—Aug. 16, 1901. No. 42934 A.

LIGHTING.

Arcs.

The Mechanism of the Electric Arc. (Mrs.) Hertha Ayrton. Abstract. The object of the paper is to show that by applying the ordinary laws of resistance all its principal phenomena can be accounted for, without the aid of a large back e. m. f., or of a "negative resistance," or of any other unusual attribute. 2200 w. Elec Rev, Lond—Aug. 16, 1901. No. 42939 A.

Carbons.

The Proper Structure for Carbon Electrodes (Ueber die Günstige Struktur von Kohlenelektroden). J. Härden. With microscopic sections showing the advantages of converting the carbon into the graphite state. 1000 w Elektrotech Zeitschr—July 18, 1901. No. 42867 B.

Illuminated Towers.

From Christmas Tree to Pan-American. Luther Stieringer. An illustrated article giving the history of electrically-illuminated towers. 3600 w. Elec Wld & Engr—Aug. 24, 1901. No. 42900.

Massachusetts.

Electrical Supply Stations in Massachusetts. Alton D. Adams. An account of the electric lighting development in this State. 2800 w. Elec Rev, N. Y.—July . 1901. No. 42448.

Nernst Lamp.

Development of the Nernst Lamp in America. Alexander Jay Wurts. Gives the results of the work, and names of those who have been connected with it, reviewing the subject in detail, and pronouncing the lamp a commercial success. Ill. 6200 w. Trans Am Inst of Elec Engrs—June & July, 1901. No. 42755 D.

Private Station.

Public Electric Lighting From a Private Station (Application à l'Eclairage Public de l'Electricité Produite par un Usine pour ses Besoins Personnels). A description of the lighting of the town of Tangermünde, on the Elbe, by current from the plant of the Meyer sugar refinery. 1800 w. Revue Technique—July 25, 1901. No. 42806 D.

Rasch Light.

The Rasch Electric Light. An account of the invention of Herr E. Rasch, of Potsdam, which consists in using the refractory materials used in the filament of the Nernst lamp to replace the carbons of the arc lamp, thus producing a beautiful, steady light equivalent to 75 per cent. of the energy applied. 1500 w. Elec Rev, Lond—July 26, 1901. No. 42519 A.

Ship Lighting.

Lighting Antarctic Ships. Brief illustrated description of the special lighting features of the British steamer "Discovery," which has just started for the South Polar regions. The driving agency is a great windmill on the upper deck. 200 w. Elec Wld & Engr—Aug. 17, 1901. No. 42712.

MEASUREMENT.

Direct Currents.

The Transformer for Measuring Large Direct Currents. Discussion of paper by Harris J. Ryan. 3200 w. Trans Am Inst of Elec Engrs—June and July, 1901. No. 42748 D.

Dynamometer.

Eddy-Current Brakes (Wirbelstrombremse). Dr. K. Feussner. A description of the use of the eddy current brake as an absorption dynamometer for testing small electric motors. 4500 w. Elektrotech Zeitschr—July 25, 1901. No. 42871 B.

Efficiency.

Approximate Methods for the Determination of Efficiency (Leistungsmessung mittels Angenäherter Methoden). G. Stern. A discussion of the errors of certain approximate methods, including the three-wire meter, and various induction meters. 4500 w. Elektrotech Zeitschr—July 18, 1901. No. 42865 B.

Indicators.

Power Factor Indicators. William Hand Browne, Jr. Describes various types of meters and indicators, considering the best method of attaining the end sought. 5300 w. Trans Am Inst of Elec Engrs—June and July, 1901. No. 42753 D.

Synchronism and Frequency Indication. Paul M. Lincoln. Describes these two devices, which were conceived and developed almost simultaneously, giving related information of interest. Ill. 4400 w. Trans Am Inst of Elec Engrs—June and July, 1901. No. 42751 D.

Wattmeter.

Thomson Recording Wattmeter. C. G. Carmichael. Read before the Engng. Soc. of the Sch. of Prac. Science, Toronto. Brief illustrated description, with comparison. 1100 w. Can Elec News—Aug., 1901. No. 42761.

POWER APPLICATIONS.

Electric Clocks.

The Barr, Stout, and Becker Electric Clocks at the Glasgow Exhibition. Illustrated description of these clocks, fourteen of which are installed at the Glasgow

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exhibition. 1100 w. Engng—July 26, 1901. No. 42525 A.

Electric Driving.

Electricity in the Union Iron Works. W. W. Hanscom. An illustrated description of this plant for power and lighting large works in San Francisco. 4000 w. Jour of Elec—June, 1901. No. 42437.

The Choice of an Electric Power Distribution System in Factories. P. R. Moses. Discusses the merits and demerits of the polyphase alternating system, and the question of best electrical pressure. 3000 w. Engineering Magazine—Sept., 1901. No. 42895 B.

Electric Hoists.

Electric Hoists on the Comstock. Leon M. Hall. Illustrates and describes a continuous rope electric hoist, driven by means of a variable speed, three-phase induction motor. 1200 w. Eng & Min Jour—Aug. 3, 1901. No. 42496.

Electricity in Machine Shops. The first of a series of articles intending to present some of the applications of the electric motor. The present article shows the commercial variable speed motor driving an engine lathe of heavy type. Ill. 1300 w. Ir Trd Rev—Aug. 8, 1901. Serial. 1st part. No. 42596.

Electric Power.

See Industrial Economics.

Elevator.

The Electric Elevator in the Washington Monument. C. M. Lewis. Illustrated description of the light and power plant, elevator machinery, etc. 4800 w. Elec Wld & Engr—Aug. 3, 1901. No. 42544.

The New Electric Elevator at the Washington Monument. Illustrated detailed description of the new elevator, with explanation of the change. 3500 w. Eng News—Aug. 22, 1901. No. 42904.

Induction Motor.

An Asynchronous Induction Motor or Generator with a Power-Factor of Unity. Alexander Heyland. From the *Electrotechnische Zeitschrift*. Describes a method of eliminating the phase difference between current and pressure, and thus at the same time doing away with the wattless magnetizing and light load currents, and the consequences of the air-gap between the stator and rotor. 2000 w. Elect'n, Lond—Aug. 16, 1901. No. 42940 A.

Mining Plant.

Electricity in Mountain Mines. Discussion of a paper by F. W. Brady. 2300 w. Trans Am Inst of Elec Engrs—June and July, 1901. No. 42749 D.

Motors.

Why a motor "Motes." An explanation of why a motor rotates, and why it rotates constantly in one direction under the same conditions. Ill. 4000 w. Power—Aug., 1901. No. 42455.

Pumping.

The Electrically Driven Pumping Plant at the Kaiserstuhl Shaft No. II. at Dortmund (Elektrisch Betriebene Wasserhaltun der Zeche Kaiserstuhl II, bei Dortmund). K. Weitzenmiller. Describing the generators, motors and pumps used in the deepening of a coal shaft, the capacity being 5 cubic metres per minute against 400 metres head. 2000 w. Glückauf—July 20, 1901. No. 42853 B.

Switches.

Some Notes on the Design of Motor-Starting Switches. F. W. Davies. Notes and a few suggestions with reference to starting-switch design. Ill. 1800 w. Elec Engr, Lond—July 26, 1901. No. 42515 A.

TRANSMISSION.

Bay Counties.

The World's Longest Electric Power Transmission. George P. Low. An illustrated popular description of the system of the Bay Counties' Power Co., in California, introductory to technical descriptions to follow. 10200 w. Jour of Elec—July, 1901. No. 42797 C.

Lighting.

Protection Against High Pressures (Schutzvorrichtungen gegen Schädliche Ueberspannungen). G. Benischke. A paper on lightning arresters and protection against high tension currents, with discussion. Presented before the Elektrotechnische Verein. 5000 w. Elektrotech Zeitschr—July 11, 1901. No. 42864 B.

The Relief of Conductors Charged With Statical Electricity (Die Ladung von Freileitungen mit Statischer Elektricität und deren Ableitung). H. Müller. A discussion of the principles involved in the construction of devices for relieving highly charged line wires. 2000 w. Elektrotech Zeitschr—July 25, 1901. No. 42870 B.

Line Performance.

Performance of an Artificial Forty-Mile Transmission Line. William S. Aldrich and George W. Redfield. An account of a test carried out in the Elec. Engng. Laboratory of the Univ. of Illinois, the results representing closely what might be expected under commercial conditions of a similar line. 4200 w. Trans Am Inst of Elec Engrs—June and July, 1901. No. 42752 D.

Long Distance.

Elements of Design Particularly Pertaining to Long Distance Transmission. F. A. C. Perrine. Discusses points arising in carrying out a long-distance transmission. 2800 w. Trans Am Inst of Elec Engrs—June and July, 1901. No. 42754 D.

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Practical Power Transmission. John Martin. Read before the Pacific Coast Gas Assn. States the conditions in California and the satisfactory service now possible within reasonable distances. Also discussion. 7200 w. Am Gas Lgt Jour—Aug. 26, 1901. No. 42784.

MISCELLANY.

Electric Furnace.

A New Electric Furnace. Concerning a furnace recently patented in England by Mr. A. Parker which appears to have solved many of the difficulties under which carbide has been made. 1400 w. Elec Rev, Lond—July 26, 1901. No. 42517 A.

Radiography.

Radio-Active Substances and Their Radiations. George B. Pegram, in *Science*. A review of the recent work in this field. 4800 w. Elec Rev, N. Y.—July 27, 1901. No. 42449.

GAS WORKS ENGINEERING

Acetylene.

Lighting by Acetylene. Frederick Dye. The present article gives an elementary outline of how acetylene is made and used. 2300 w. Plumb & Dec—Aug. 1, 1901. Serial. 1st part. No. 42638 A.

Railway Lighting by Acetylene Gas. John S. Seymour. Explains a system of lighting by this gas, discussing its advantages. 2300 w. Ry & Engng Rev—Aug. 24, 1901. No. 42796.

Address.

Inaugural Address Before the North British Association of Gas Managers. W. R. Herring. Discusses modern methods and questions of interest to the gas industry. 4700 w. Jour Gas Lgt—July 30, 1901. No. 42577 A.

Benzols.

Composition, Examination, and Application of Benzols. Dr. F. Frank, in *Chemische Industrie*. Abstract from the *Journal of the Society of Chemical Industry*. Explains methods of testing commercial benzols. 1500 w. Jour Gas Lgt—Aug. 6, 1901. No. 42721 A.

Carbonization.

Influence of the Physical Condition of Coal on the Quality of the Products of Carbonization. M. Verdier. Read at the meeting of Société Technique. Gives investigations, results, and conclusions. 1200 w. Jour Gas Lgt—Aug. 6, 1901. No. 42720 A.

Coals.

Coals: Their Composition, Properties and Uses. W. Ivison Macadam. Lecture before the Irish Assn. of Gas Mgrs. Considers the formation, composition, calorific power, weight of gases and photometric tests. 3500 w. Gas Wld—Aug. 17, 1901. No. 42944 A.

Diluting Gases.

The Economical Production of Diluting Gases. C. B. Tully. Read before the Irish Assn. of Gas Mgrs. An account of interesting work at Sligo, with discussion. Ill. 2800 w. Gas Wld—Aug. 7, 1901. No. 42943 A.

Distribution.

Modern Methods of Distributing Gas. Norton H. Humphreys. An explanation of the methods and motive power for distributing systems. 3400 w. Jour Gas Lgt—Aug. 13, 1901. No. 42745 A.

Domestic Fuel.

Promotion of Domestic Fuel Gas Consumption. R. P. Valentine. Read before the Pacific Coast Gas Assn. Suggestions for increasing the demand for gas as a fuel. 1800 w. Am Gas Lgt Jour—Aug. 12, 1901. No. 42633.

Enrichment.

Gas Enrichment. A. Yuill. Read before the N. Brit. Assn. of Gas Mgrs. Deals especially with enrichment by benzol. 2000 w. Jour Gas Lgt—July 30, 1901. No. 42578 A.

Gas Enrichment. Discussion of paper by A. Yuill. 5000 w. Jour Gas Lgt—Aug. 6, 1901. No. 42718 A.

Gasholder.

A Giant Gasholder and Its Erection. Illustrated detailed description of the erection of a large gasholder for the East River Gas Company of New York. 2000 w. Ir Age—Aug. 22, 1901. No. 42742.

Gas Strike.

History of the Cork Gas Strike. A summary of the official history prepared by the directors, giving a glimpse into the conditions under which the works were carried on. 2300 w. Gas Wld—Aug. 10, 1901. No. 42725 A.

Improvements.

Modernizing the Carbonizing Plant at the Chester Gas-Works. An illustrated description of interesting alterations. 2000 w. Jour Gas Lgt—July 30, 1901. No. 42580 A.

International Congress.

Report on the International Congress of the Gas Industry (Paris, France, Septem-

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ber, 1900), to the Pacific Coast Gas Association. J. B. Grimwood. 5400 w. Am Gas Lgt Jour—Aug. 12, 1901. No. 42631.

Lecture.

Light. Prof. Ivison Macadam. Lecture delivered before the N. Brit. Assn. of Gas Mgrs. Gives information on the analysis of light, testing, different burners, and the Welsbach, or incandescent burner, with general conclusions. 3200 w. Jour Gas Lgt—July 30, 1901. No. 42579 A.

Natural Gas.

A Furnace System Using Natural Gas. Illustrated description of a heating system in residence at Wheeling, W. Virginia. 1800 w. Met Work—Aug. 10, 1901. No. 42595.

Purifier-Boxes.

Expanded Metal for the Construction of Purifier-Boxes. P. Bachelay. Read at meeting of the Société Technique. A note on the use of this material and its advantages. Ill. 800 w. Jour Gas Lgt—July 30, 1901. No. 42581 A.

Retort-Charging.

A Retort-Charging Machine. A. Cabrier. Presented at meeting of the Société Technique. Illustrates and describes the machine, explaining its principle and method of working. 900 w. Jour Gas Lgt—Aug. 13, 1901. No. 42746 A.

Scrubber.

A New Type of Scrubber. R. W. B. Creeke. Read at meeting of the N. Brit. Assn. Traces briefly the changes which have taken place in scrubbers, defining the difference between a scrubber and a washer, and giving an illustrated description of a new machine scrubber. Discussion. 3800 w. Jour Gas Lgt—Aug. 6, 1901. No. 42719 A.

Subways.

Concrete Subways for Underground Pipes. Extracts from a paper by Arthur Taylor Allen read before the Society of Engineers. Illustrates and describes a suggested construction, with its lighting, ventilation, etc. 3200 w. Gas Wld—Aug. 10, 1901. No. 42726 A.

Tunnels.

Subaqueous Tunnels for Gas Conduits. W. W. Cummings with discussion. Illustrated description of methods of construction used in three river crossings recently carried out by the Massachusetts Pipe Line Gas Co. 8 plates. 7500 w. Jour Assn Engng Socs—June, 1901. No. 42593 C.

Water Gas.

Water Gas Installation on the Strache System. Details of the more important plants erected on a working scale and the results obtained. Ill. 4600 w. Jour Gas Lgt—Aug. 20, 1901. Serial. 1st part. No. 42973 A.

MARINE AND NAVAL ENGINEERING

Battleships.

Modernizing Battleships. S. Eardley-Wilmot. Discusses the reconstruction of these vessels, alluding to the practice of France, and Austria, and the course that should be taken by England. 2000 w. Naut Gaz—Aug. 22, 1901 No. 42783.

The Construction of War Ships (Ueber den Bau von Kriegschiffen). H. Hüllman. A discussion of the general problems of design, equipment, armament, etc., based on the development of the German Navy. 6000 w. Zeitschr d Ver Deutscher Ing—Aug. 17, 1901. No. 42834 D.

The New Battleship Design Controversy. Gives a sheer plan and deck plan of each design, with a diagram showing the maximum concentration of fire possible from the intermediate and secondary batteries of each vessel, with discussion of the arguments. 2200 w. Sci Am—Aug. 10, 1901. No. 42587.

Boilers.

See Mechanical Engineering, Steam Engineering.

Chain-Steamer.

Chain-Steamer of the Royal Bavarian Line Upon the Upper Main River, Germany. Abstracted from an article by Eduard Weiss, in *Zeitschrift des Vereines Deutscher Ingenieure*. Illustrated detailed description of sprocket-wheel type of ship, with turbine propellers, its equipment and operation. 2200 w. Eng News—Aug. 1, 1901. No. 42480.

Clipper Ship.

Details of Construction of the Famous American Clipper Ship Great Republic. Reprint of a description of this vessel written at the time of her construction, about fifty years ago. Ill. 2900 w. Marine Engng—Aug., 1901. Serial. 1st part. No. 42492 C.

Dry Docks.

The Floating Dry-Dock at Havana. An illustrated general description of this steel dock bought of the Spanish government for $185,000, and intended for use in the Philippine Islands. 3200 w. Marine Rev—Aug. 8, 1901. No. 42624.

We supply copies of these articles. See page 159.

Explosives.

High Explosive Shells. Editorial concerning some experiments made by Sir Hiram Maxim, with discussion of other explosives. 2700 w. Engng—Aug. 2, 1901. No. 42645 A.

Ferryboat.

Fine New Ferryboat. Illustration, with description, of the Lakewood, a double-screw ferryboat for N. Y. harbor, belonging to the Cent. R. R. of N. Jersey. 900 w. Naut Gaz—Aug. 22, 1901. No. 42782.

The Northfield Accident. Brief illustrated account of the damage to this ferryboat while leaving New York on June 14, by the "Mauch Chunk" colliding. 500 w. Marine Engng—Aug., 1901. No. 42490 C.

Folding Boat.

The "James" Folding Boat. Illustrated description of a boat which received the approval of the British Board of Trade under the Life Saving Appliances Act. 1000 w. Ind & East Engr—July, 1901. No. 42717 B.

Framing.

The Computation of Statistically Indeterminate Systems in Shipbuilding (Berechnung Statischer Unbestimmter Systeme in Schiffbau). Franz Kretschmar. A mathematical study of the statics of framed structures applied to the design of ship framings. Serial. Part I. 2000 w. Schiffbau—July 23, 1901. No. 42-859 D.

Ironclads.

Modernizing Ironclads. S. Eardley-Wilmot. Discusses what is to be done with out-of-date ships of this class. 1800 w. Engr. Lond—Aug. 2, 1901. No. 42-647 A.

Launching.

Novel Means of Launching a Vessel. Illustrates and describes the method used in restoring light-ship No. 50 to the water, after being high and dry upon the beach. 1200 w. Marine Rev—Aug. 1, 1901. No. 42501.

Lengthening.

Lengthening of the S. S. "Iroquois." An illustrated description of work of cutting and lengthening a steamship, carried out at the Erie Basin, New York. 1000 w. Sci Am—Aug. 31, 1901. No. 42970.

Load Line.

Determination of the Line of Flotation of a Ship for Variable Loading (Bestimung der Schurinm linie eines Schiffes bei Trimänderungen). J. Meyer. A mathematical investigation in rectangular coordinates, with diagrams for various forms of hulls. 2000 w. Schiffbau—Aug. 8, 1901. No. 42861 D.

Marine Railroad.

The Largest Marine Railroad in the World. Ralph C. Davison. An illustrated description of the cradle, the ways and the hauling-out gear, etc., with statement of the advantages. 1200 w. R R Gaz—Aug. 9, 1901. No. 42610.

Naval Engineers.

The Position of Naval Engineers. Report of the arguments submitted to the First Lord of the Admiralty in England, by a deputation representing the N. E. Coast Inst. of Engrs. & Shipbuilders, the Inst. of Marine Engrs., London, and Inst. of Marine Engrs. (South Wales). 8000 w. Engr, Lond—July 26, 1901. No. 42-533 A.

Navigation.

On Sea Charts Formerly Used in the Marshall Islands, with Notices on the Navigation of These Islanders in General. Capt. Winkler. 4500 w. Ill. Sci Am Sup—Aug. 31, 1901. No. 42972.

Ocean Ships.

A Brief History of Ocean Passenger Ships. Lawrence Irwell. An interesting review of this service from its beginning. 6000 w. Marine Rev—Aug. 1, 1901. Serial. 1st part. No. 42502.

The White Star Liner "Celtic." Illustrations and interesting information concerning this vessel, the largest yet built. 1400 w. Sci Am—Aug. 17, 1901. No. 42667.

Review.

Review of Marine Engineering During the last Ten Years. James McKechnie. An interesting review of the development, with 11 plates and other illustrations, 15 tables and much information. 10600 w. Inst of Mech Engrs—Aug, 1901. No. 42-588 D.

Screw Propulsion.

Pioneer Screw Vessels of the Lakes. Illustrations and notes from Samuel R. Kirby, concerning early vessels. 800 w. Marine Rev—Aug. 8, 1901. No. 42635.

The Evolution of the Screw Steamer. Benjamin Taylor. Gives Col. John Stevens the credit of being the first to apply steam as a motive power to screw propellers, and discusses the origin and development. Ill. 2800 w. Marine Rev—Aug. 15, 1901. No. 42704.

Shamrock II.

The Eleventh Challenger for the America Cup—Shamrock II. Illustrated article discussing features of this fine yacht, with editorial. 2200 w. Sci Am—Aug. 24, 1901. No. 42773.

Shipbuilding.

A Century of Steam Ship Building. From the *Monthly Review* (England).

We supply copies of these articles. See page 159.

The present year is the hundredth anniversary of the use of steam as a motive power for ships, and a review of the development is given. 4200 w. Marine Rev—Aug. 22, 1901. No. 42775.

Naval and Merchant Ship Construction in the United States During the Past Year. Abstracted from the introduction to the "Blue Book of American Shipping." 1500 w. Eng News—Aug. 15, 1901. No. 42695.

The Arrangement and Equipment of Shipbuilding Works. James Dunn. Discusses the general principles dominating the plan of shipbuilding works, tools and their arrangement, closed-in versus open berths and the cranes serving them, etc. Tables and 12 plates. 7700 w. Inst Mech Engrs—Aug., 1901. No. 42591 D.

Ship Design.

Form Calculations from Lines of Ships. Theodore Lucas. The first of a series of articles dealing with the lines of ships. 1500 w. Naut Gaz—Aug. 8, 1901. Serial. 1st part. No. 42583.

Shipyards.

Shooters Island Shipyard. Illustrated description of the works covering this island, at the mouth of Newark Bay. 1100 w. Marine Engng—Aug., 1901. No. 42493 C.

The Steel Ship Yards of the United States. Waldon Fawcett. Illustrated article giving information concerning the shipyards of the South. 1400 w. Am Mfr—Aug. 8, 1901. No. 42636.

Steamships.

The Steamship M. S. Dollar. Illustrated description of this recently launched vessel of the three deck type. Also describes the engines. 1200 w. Marine Engng—Aug., 1901. No. 42491 C.

Submarine.

Submarine Boats (Onderzeeche Booten). H. H. Versteegh. A general historical review, together with some account of recent submarines. Two articles. 5000 w. De Ingenieur—July 20, 27, 1901. No. 42846 each D.

Tender.

Fine New Light-House Tender. An illustrated description of the "Larkspur" now building. 1600 w. Naut Gaz—Aug. 15, 1901. No. 42705.

Testing Tank.

The Ship-Model Testing Tank in Use at the Denny Ship-yard in England. Extract from an article in the *N. Y. Herald*, by J. D. Jerrold-Kelley, giving an account of the new system of testing ships' models in this private testing tank. 2000 w. Naut Gaz—Aug. 8, 1901. No. 42584.

Torpedo Boats.

The Standardization and Contract Trials of the U. S. Torpedo Boats Bagley and Barney. Brief description with data of trials. 900 w. Marine Engng—Aug., 1901. No. 42494 C.

Transport.

The United States Transport "Sumner." An illustrated description of the work of conversion, and the completed ship. 2500 w. Engng—Aug. 16, 1901. No. 42957 A.

Yukon Route.

The Talbiksak River: A Possible Shortening of the navigable route of 320 miles, thus avoiding the most dreaded part of the Bering Sea, and making it possible to enter the region two weeks earlier. 1600 w. Eng News—Aug. 22, 1901. No. 42913.

MECHANICAL ENGINEERING

AUTOMOBILES.

Automobile Test.

Regulations for the First Long Distance International Automobile Test in America. Rules and regulations for the 500-mile. New York-Buffalo endurance test to occur in Sept. 3000 w. Elec Wld & Engr—Aug. 3, 1901. No. 42545.

Automobiling.

Automobiling in the West. Charles B. Shanks. An illustrated account of experiences encountered during the attempt made by Alexander Winton to cross the North American continent in an automobile. 3800 w. Sci Am Sup—Aug. 3, 1901. No. 42478.

Balancing.

Balancing Double Cylinder Motors. From *La France Automobile*. Explains a system devised by Panhard & Levassor to absolutely balance the rotary parts of a motor. Ill. 600 w. Horseless Age—Aug. 28, 1901. No. 42962.

Bicycles.

Motor Bicycle Design. Douglas Leechman. Deals with the adaptation of the safety bicycle to motor driving, considering the position of the motor, steering, side-slip, etc. Ill. 3500 w. Autocar—July 27, 1901. No. 42512 A.

British Law.

The Maybach Carburetter Case. Discusses this case, which is of interest to the automobile industry, from the technical, legal, and commercial points of view. 7700 w. Auto Jour—Aug. 1901. No. 42931 A.

Electric Vehicles.

Electric Automobilism (L'Automobilisme Electrique). Felix Colomer. An ex-

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amination of the availability of electric accumulators for driving motor vehicles with especial reference to the Contal accumulator. 2000 w. Revue Technique—Aug. 10, 1901. No. 42809 D.

The "Electricia" Carriages. From *La Nature.* An illustrated description of interesting features of these vehicles. 1300 w. Sci Am Sup—Aug. 17, 1901. No. 42670.

Endurance Test.

Road Description of the 500-Mile Endurance Test. Maps, road description and general instructions, as compiled by the committee having charge of this contest between New York and Buffalo. 6200 w. Auto Mag—Sept., 1901. No. 42925 C.

Fire Engines.

Self-Propelled Fire Engines. Waldon Fawcett. Illustration and information concerning these engines as used in Boston. 800 w. Sci Am—Aug. 17, 1901. No. 42669.

Fuel Feeding.

Feeding Fuel to Cylinder-Fired Motors. Hugh Dolnar. Illustrated information of appliances for regulating the flow, showing the superiority of these various mixing valves to the older forms of carburetters. 2200 w. Autocar—Aug. 10, 1901. No. 42723 A.

Gasoline Vehicles.

Remodeling a Gasoline Vehicle. Albert L. Clough. Describes changes made and reasons for making them. 1000 w. Horseless Age—Aug. 21, 1901. No. 42763.

The Gasoline Carriage of the United States Long Distance Automobile Company. Illustrated description of a carriage of the intermediate class, both as regards weight and engine speed. 900 w. Horseless Age—Aug. 14, 1901. No. 42696.

The Kühlstein-Vollmer Gasoline Vehicle. Illustrated description of a vehicle made by these German manufacturers. 1300 w. Horseless Age—Aug. 7, 1901. No. 42586.

The Mercedes Carriage. Illustration and particulars of this powerful gasoline vehicle. 2700 w. Horseless Age—Aug. 21, 1901. No. 42762.

Motor.

The Kühlstein Vollmer Motor. From *Der Motorwagen.* Illustrated description. 700 w. Horseless Age—Aug. 28, 1901. No. 42963.

Motor Cars.

Some Work in the Development of a Motor-Car. M. Holroyd Smith. A description of the work involved in the construction of the latest Petrol car designed and built by the author, with deductions therefrom. 4 plates and other illustrations. 5500 w. Inst Mech Engrs—Aug., 1901. No. 42589 D.

The Gaillardet Motor Car. Illustrates and describes these vehicles which differ in details from most other manufacturers. 900 w. Auto Jour—Aug. 1901. No. 42933A.

Motor Cycles.

Reflections on Motor Cycles. Albert L. Clough. Conclusions of the writer after a 60-mile trip on a motor tricycle. 2000 w. Horseless Age—Aug. 7, 1901. No. 42585.

Musker System.

The Coke and Oil-Fired Musker System. Illustrated descriptions of the steam wagons of this firm, which took part in the recent heavy wagon trials at Liverpool. 1200 w. Auto Jour—Aug., 1901. No. 42932A.

Steam Carriage.

Working Drawings of a Steam Carriage. T. Hyler White in *The English Mechanic.* Begins the description of a carriage incorporating the latest ideas, and which may be built at a fairly low cost. 2000 w. Horseless Age—July 31, 1901. Serial. 1st part. No. 42463.

Thunderstorms.

Is an Autocar Safe in a Thunderstorm? Sidney F. Walker. Explains the electrical discharge during a thunderstorm, and the conditions needed for safety. 2500 w. Autocar—Aug. 17, 1901. No. 42926A.

Tires.

Side Stresses and Braking Efforts on Tires. Albert L. Clough. An examination of stresses which might occur in the use of motor vehicles. 1000 w. Horseless Age—July 31, 1901. No. 42462.

HYDRAULICS.

Centrifugal Pumps.

The Testing of Centrifugal Pumps (Beproeving van Kreiselpumpen). M. C. E. Bongaerts. A description of the Neukirch method, maintaining a constant level of head against the pump, the latter being driven by an electric motor. 1200 w. De Ingenieur—Aug. 10, 1901. No. 42849D.

Compression.

See Mining and Metallurgy, Iron and Steel.

Flow.

Comparison of Formulas for Flow of Water in Clean Cast-Iron Pipes. Frank S. Bailey. Gives a table of computed velocities and explanatory notes. 700 w. Eng News—Aug. 15, 1901. No. 42685.

Intensifiers.

Hydraulic Intensifiers. Gerald E. Flanagan. Explains what an intensifier is, and its operation. Ill. 900 w. Am. Mach—Aug. 22, 1901. No. 42766.

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Plumbing.

The Plumber as a Sanitary Expert. James Allison. Explains why legislation is needed to control this industry, and the importance of education. 2500 w. Dom Engng—Aug. 15, 1901. No. 42702 C.

Plumbing in a New York Residence. Illustrated description of a job with an unusually simple arrangement of water piping and no kitchen and laundry boilers. 800 w. Eng Rec—Aug. 3, 1901. No. 42540.

Power Development.

The Water Power Plant of the Empire State Power Company. Illustrated description of a 3,000-H. P. plant on a 40 ft. fall, the water being carried from the dam through a long canal and short penstocks. Power is transmitted to Howes Cave and to Amsterdam, N. Y. 3400 w. Eng Rec—Aug. 10, 1901. No. 42614.

Pumping Engines.

Pumping Engines at Hampton. Detailed description of these engines, which are fully illustrated. 900 w. Engr, Lond—Aug. 2, 1901. No. 42652A.

The Riedler Pumping Engine. An account of an inspection of two pumps at work. Ill. 1600 w. Col Guard—Aug. 16, 1901. No. 42955A.

Ram.

A Large Hydraulic Ram. Daniel W. Mead. Describes the water-works system at West Dundee, Ill., and gives illustrated description of the hydraulic ram used to force the water into the tower. 1000 w. Eng Rec—Aug. 24, 1901. No. 42918.

Turbines.

Inward-Flow Turbines. Illustrated description of these turbines which, when tested, reached 85½ per cent. total efficiency. Also report of tests. 2400 w. Engr, Lond—Aug. 16, 1901. No. 42950A.

The 3000 Horse Power Turbines at Niagara (Die 3000-pferdigen Turbinen Am Niagara). R. Thomann. A detailed description of two horizontal Francis turbines built by Riva, Monneret & Co., of Milan, Italy, for the Hamilton Electric Light and Contract Power Co., of Canada. 1800 w. Zeitschr d Ver Deutscher Ing—Aug. 3, 1901. No. 42826 D.

MACHINE WORKS AND FOUNDRIES.

Angle Rolls.

The Design of Angle Rolls. William Hirst. Discusses important points in rolling, the designs of rolls for making angles, the early forms of passes, &c. Ill. 3700 w. Ir Age—Aug. 8, 1901. Serial. 1st part. No. 42570.

Boiler Making.

A Method of Developing the Slope Sheet of a Locomotive Boiler When Center of the Cone is Inaccessible. Frank B. Kleinhaus. Illustrated description of method used. 500 w. Loc Engng—Aug., 1901. No. 42443C.

On Circular, Stay-bolted Water Legs. A mathematical explanation of the method of deriving formulæ used in a former article, which have been criticized. 1600 w. Locomotive—June, 1901. No. 42672.

Brass Castings.

Thin Brass Castings. C. Vickers. Discusses the difficulties in this work, giving suggestions. 1000 w. Am Mach—Aug. 15, 1901. No. 42699.

Cast Iron.

Standard Specifications for Testing Cast Iron. Specifications adopted by the Am. Found. Assn., with recommendations of the committee relative to the molding of the test bars, &c. Ill. 2100 w. Jour Am Found Assn—June, 1901. No. 42656.

Cast-Iron Pipes.

French Practice in the Manufacture of Cast-Iron Pipes. A. G. Cloake. Read at meeting of Assn of W. Wks. Engrs. Describes the practical and workmanlike methods; the pipes are cast vertically. 2000 w. Arch't, Lond—Aug. 16, 1901. No. 42924A.

Cranes.

Cantilever Cranes at the Yard of William Cramp & Sons' Ship and Engine Building Company. Illustrated description of new equipment for handling materials consisting of three cantilever cranes driven by electricity and covering six shipways. 500 w. Marine Engng—Aug., 1901. No. 42495C.

Modern Heavy Harbour Cranes (Moderne Hafen und Werftkrane—Schwerster Konstruktion). H. Mehlis. With details and illustrations of the latest heavy wharf cranes at Hamburg, Bremen and other places. 2500 w. 2 plates. Glaser's Annalen—Aug. 15, 1901. No. 42831D.

Modern Lowering Brakes for Cranes (Kritik der Neueren Senksperrbremsen für Krane). Ad. Ernst. A description of the various forms of safety brakes for cranes and hoisting machinery by which the load may be lowered without danger. Two articles. 7500 w. Zeitschr d Ver Deutscher Ing—Aug. 3, 10, 1901. No. 42825 D.

Novel Cranes. Waldon Fawcett. Describes some recent modifications and improvements. Ill. 1100 w. Am Mfr—Aug. 15, 1901. No. 42683.

Dies.

A Combination Die for Shallow Rectangular Shells. William Doran. Illustrates and describes the design and construction. 2300 w. Am Mach—Aug. 29, 1901. No. 42966.

A Twisting Die. C. H. Rowe. Draw-

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ings and description of a die made for twisting the ends of sheet brass, 1/16 inch thick and 3/16 inch wide, but also adapted for other work. 700 w. Am Mach—Aug. 1, 1901. No. 42458.

Dies for Umbrella Rib Tips. William Doran. Illustrated description of dies for the work named and adapted for the rapid production of other small sheet-metal parts 900 w. Am Mach—Aug. 1, 1901. No. 42459.

Electric Driving.

See Electrical Engineering, Power Applications.

Forging Press.

Press of 1000 Tons Capacity for Compressing Steel Ingots (Presse de 1000 Tonnes pour la Compression de Lingots d'Acier). With sectional illustrations of the powerful press used at the St. Etienne Steel Works, France. 1800 w. Génie Civil—Aug. 10, 1901. No. 42804D.

Gun Mounting.

Vickers' Gun-Mounting Works at Barrow-in-Furness. Illustrated detailed description of the various departments of these extensive works. 5000 w. Engng—July 26, 1901. No. 42524A.

Lathes.

A Large German Crank Shaft Lathe. Half-tone and line engravings of what is believed to be the largest lathe that has been made. Description. 700 w. Am Mach—Aug. 29, 1901. No. 42964.

Design for Special Screw Cutting Lathe. M. W. Leech. Drawings and description of a design for cutting short fine threads used on mountings for instrument work. 350 w. Am Mach—Aug. 22, 1901. No. 42768.

Lathe for Double Crank Shafts (Doppelte Kurbelachsen-Drehbank). Illustrated description of heavy double ended lathe built by E. Schiess of Düsseldorf, for turning heavy multiple-crank shafts for marine engines. 1000 w. Stahl und Eisen—Aug. 1, 1901. No. 42840 D.

The Three-Bearing Lathe. A. H. Cleaves. Illustrates and describes a lathe called in the watch factory, a plate lathe. 400 w. Am Mach—Aug. 29, 1901. No. 42967.

Milling Machine.

A Screw-Milling Machine. Illustrates and describes machines for cutting screw threads entirely by the use of milling cutters. 1300 w. Am Mach—Aug 22, 1901. No. 42767.

Milling Tools.

A Device for Measuring Angle Cutters. Horace E. Hext. An account of methods attempted for determining accurately the angle of a milling cutter, with illustrated description of the device which gave satisfactory results. 1700 w. Am Mach—Aug. 1, 1901. No. 42460.

Molding.

Molding Gap Lathe Beds. George Buchanan. Illustrates and describes the method used. 800 w. Am Mach—Aug. 29, 1901. No. 42968.

Pig Iron.

Discussion on the Grading of Pig Iron. 19200 w. Jour Am Found Assn—June, 1901. No. 42657.

Shaft.

Crank Shaft (Kurbelwelle). Brief description, with full detailed drawing of a four-crank shaft for a marine engine made by the Oberbilk Steel Works, Düsseldorf, for Blohm & Voss. The cranks are arranged for counter balancing on the Schlick system. 500 w. 1 plate. Schiffbau—July 23, 1901. No. 42860 D.

Shearing.

Experiments on the Work of Machine Tools (Expériences sur le Travail des Machines-Outils). M. Codron. A study of the action of tools in shearing various metals with analysis of the external and internal forces. 8000 w. Bull Soc d' Encour—July 31, 1901. No. 42820G.

Shops.

American Machine-Shop Practice from a German View-Point. Peter Lüders. Discusses American manufacturing conditions, the equipment of the shops, organization, and the unity of engineer and workman. 2400 w. Engineering Magazine—Sept., 1901. No. 42896B.

The New Works of the Becker-Brainard Milling Machine Company. Illustrated detailed description of these works and some of the equipment. 2700 w. Mach, N. Y.—Aug., 1901. No. 42450.

Spacing.

Spacing for Prime Numbers on the Universal Milling Machine. G. Schneider. An explanation of three methods used by the writer. Ill. 2400 w. Am Mach—Aug. 8, 1901. No. 42571.

Spacing the Teeth of a Rack. Illustrates and describes a spacing attachment that will space the teeth of any diametral pitch. 500 w. Am Mach—Aug. 15, 1901. No. 42697.

Universal Joint.

A New Variable-Angle Joint (Sur un Nouveau Joint à Angle Variable). G. Koenigs. A description of an improvement on the Cardan joint, by means of which a uniform angular velocity is transmitted. 1000 w. Comptes Rendus, July 15, 1901. No. 42836 D.

Valves.

Discussion of Mechanical Versus Poppet Valves for Air Compressors. J. A. Coombs. A letter giving the views of an

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English manufacturer of this class of machinery, with editorial. 1500 w. Compressed Air—Aug., 1901. No. 42673.

MATERIALS OF CONSTRUCTION.

Abrasives.

Abrasive Materials. Joseph Hyde Pratt. Considers all the natural products used for abrasives; also the artificial products of carborundum and crushed steel. 5700 w. Am Mfr—Aug. 1, 1901. Serial. 1st part. No. 42564.

Aluminum.

The Method and Results of the Study of Aluminum and its Alloys (Methoden und Resultate der Untersuchung des Aluminums und Seiner Abkömmlinge). Abstract of an address of Prof. Tetmaier before the Association for Testing Materials at Zurich. 2000 w. Stahl und Eisen—Aug. 1, 1901. No. 42841 D.

Testing.

Official Testing Laboratories (Les Laboratoires Officiels d'Essais). A comparative review of the official testing laboratories of Berlin, Munich, Dresden, Vienna, and Prague, with estimates for the establishment of a laboratory in Paris. 3000 w. Revue Technique—July 10, 1901. No. 42814 D.

The Drop Flexure Test for Metals (l'Essai des Metaux à la Flexion par Choe). M. G. Charpy. A discussion of experiments made upon nicked bars by use of a pendulum drop. The relation of such tests to other methods are discussed. 8000 w. 1 plate. Mem Soc Ing Civ de France —June, 1901. No. 42816 G.

Torsion.

The Determination of the Maximum Shearing Stress in a Bar Under Torsion (Bestimmung der Grössten Schubspannung in Querschnitt eines Geraden auf Drehung Beanspnichten Stabes). E. Autenrieth. A mathematical examination of the external and internal forces in a rod subjected to torsion. 4000 w. Zeitschr d Ver Deutscher Ing—Aug. 3, 1901. No. 42827 D.

POWER AND TRANSMISSION.

Coal Handling.

Modern Coal Handling Machinery. Waldon Fawcett. Reviews the recent improvements in apparatus for this purpose. Ill. 2000 w. Am Mfr—Aug. 22, 1901. No. 42788.

The Progress of Penarth Dock. Illustrated description of the movable coal tips recently opened, and their operation. 2300 w. Engr, Lond—July 26, 1901. No. 42531 A.

Compressed Air.

The Billancourt Compressed Air Station (Usine de Billancourt pour la Production de l'Air Comprimé). G. Boeto. A fully illustrated description of the compressing station of the Paris Omnibus Company. 4000 w. 1 plate. Génie Civil —July 20, 1901. No. 42800 D.

Contractor's Plant.

The Contractor's Power Plants on the New York Rapid Transit Railway. Illustrated descriptions of eight stations, built as a rule in cramped situations, for supplying compressed air for hoisting engines, drills and other apparatus. 4200 w. Eng Rec—Aug. 3, 1901. No. 42538.

The Norwich Hydraulic Compressed Air Plant. Illustrated detailed description of an interesting plant to furnish compressed air through 3 miles of 16-inch plain cast-iron pipe to power users in Norwich. 2000 w. Eng Rec—Aug 24, 1901. No. 42916.

Conveyors.

Chain-Belt Conveyors for Wood-Working Plants. Illustrates and describes two special forms of conveyors for the handling of materials. 600 w. Eng News—Aug. 8, 1901. No. 42603.

Locomotive Coal and Ashes Handling Plant, Philadelphia and Reading Ry., Philadelphia, Pa. Illustrated description of the construction and operation. 800 w. Eng News—Aug. 15, 1901. No. 42688.

Gear Teeth.

The Effect of the Angle of Obliquity in Fixing the Interference Limits for Involute Teeth. Robert A. Bruce. Diagrams and explanation of the theory extended to cover the case of special pairs of wheels. 1200 w. Am Mach—Aug. 29, 1901. No. 42965.

SPECIAL MOTORS.

Binary Engine.

The Josse Waste Heat Engine. Illustrated description of an engine whose purpose is to utilize the waste heat of a steam engine. Editorial comments. 3300 w. Elec Wld & Engr—Aug. 10, 1901. No. 42628.

Gas Engines.

The Horse Power of Gas Engines. Discusses the need of a more definite and uniform basis of comparison. 1800 w. Prac Engr—Aug. 16, 1901. No. 42929 A.

Power Gas.

Gas Engines for Furnace Gas (Les Moteurs à Gas des Hauts Fourneaux). J. Deschamps. With illustrations of large gas engines used with furnace gases for driving blowing engines and for the production of power. Serial. 5000 w. Revue de Mécanique—July 31, 1901. No. 42819 E + F.

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STEAM ENGINEERING.

Accidents.

Water in Engine Cylinders. An account of accidents due to this cause, with suggestions for avoiding them. Ill. 1600 w. Power—August, 1901. No. 42454.

Blow-Off Tanks.

Blow-Off Tanks for Steam Boilers. Harold W. Barker. Discusses the damage to sewers from the hot water from boilers, and gives an illustrated description of a tank for cooling the water to a safe temperature before it enters the sewers. 600 w. Prac Engr—Aug. 16, 1901. No. 42928 A.

Boilers.

Navy Boilers. Editorial discussion of the letter from Mr. Delaunay Belleville, addressed to the Secretary of the British Admiralty, in defense of the Belleville boiler. 3500 w. Engng—July 26, 1901. No. 42526 A.

The Improved Boiler of F. Schichau of Elbing (Ein Neuer Kesseltyp der Firma F. Schichau in Elbing). Describing an improved form of water-tube boiler, especially adapted for marine use. 1200 w. Schiffbau—July 23, 1901. No. 42858 D.

The Marine Water-Tube Boiler. John Platt. Discusses their adaptability to large units and emergency service, and the excellent results obtained from their use in torpedo boats and destroyers where boilers are forced. Urges that more attention be paid to the possibilities of the express type of boiler. 2400 w. Engineering Magazine—September, 1901. No. 42892 B.

The Water-Tube Boiler Question in the German Navy. Translated and condensed article by Mr. Koehn von Jaski, published in the *Marine Rundschau*. Discusses the origin of the water-tube boiler question, reasons for their introduction, their disadvantages, choice of the systems, equipment of German vessels, experience, etc. 4000 w. Naut Gaz—Aug. 1, 1901. No. 42473.

The "Minerva" and "Hyacinth" Trials. Editorial on the trials of these cruisers, discussing the boilers as tested, with remarks on the ships, and their performance. 1100 w. Engng—July 26, 1901. No. 42527 A.

The "Minerva" and the "Hyacinth." Editorial discussion of the competitive trials of these cruisers. 1700 w. Engr Lond—July 26, 1901. No. 42532 A.

The Selection of a Steam Boiler. W. E. Snyder. Considers the generation of steam, the transference of the heat from the furnace to the boiler. Urging that the selection, construction and erection of the boilers be intrusted to a competent engineer of wide experience. 14400 w. Pro Engrs' Soc of W. Penn.—June, 1901. No. 42777 D.

Two New Water-Tube Boilers. Illustrates and describes the Parker water-tube boiler, and also the Hammond boiler. 1400 w. Eng News—Aug. 22, 1901. No. 42912.

Boiler Room.

Boiler Room Efficiencies. William D. Ennis. Discusses the losses and methods of securing a decrease in the waste. 3000 w. Am Elect'n—Aug., 1901. No. 42466.

Boiler Testing.

A Few Points on Practical Boiler Testing. John W. Fletcher. On the proper method of testing any boiler, land or marine, new or old. 700 w. Sci Am—Aug. 31, 1901. No. 42971.

Compression.

The Laws of Expansion and Compression (Sur les Lois de la Détente es de la Compression). V. Dwelshauvers-Dery & A. Duchesne. An examination of the principles involved in the compression of steam in an engine cylinder, with experiments sustaining the author's opinion of the wastefulness of clearance. 4000 w. Revue de Mécanique—July 31, 1901. No. 42818 E + F.

Exposition.

Steam Engines at the Paris Exposition (Die Dampfmaschinen der Pariser Weltausstellung). L. Czischek. The first of a series of illustrated articles describing the various steam engines exhibited at Paris, with critical comments. Serial. Part I. 2000 w. Zeitschr d Oesterr Ing u Arch Ver—July 19, 1901. No. 42828 B.

The Engines of the Pan-American Exposition. Illustrated descriptions of engines exhibited in operation. 6000 w. Power—Aug., 1901. No. 42452.

Feed Water.

Acid in Monongahela River Water. J. A. Mohr. Discusses the use of water from this river, for boiler purposes, giving analyses, method of testing, &c., 1200 w. Pro Engrs' Soc of W. Penn.—June, 1901. No. 42778 D.

Fuel Oil.

Oil as a Fuel. William Kennedy, in *Southern Industrial and Lumber Review*. Discusses the effect of location on the cost, methods of burning, and the uses to which it may be applied. 2000 w. Am Gas Lgt Jour—Aug. 5, 1901. No. 42553.

Piston.

Centering a Piston. H. H. Kelley. Illustrated suggestions for doing this work. 2200 w. Engr, U. S. A.—Aug. 1, 1901. No. 42497.

Portable Engine.

Tests of the Wolf Compound Portable Engine (Bremsversuche an einer von R. Wolf Gebauten Heissdampf-Verbund loko-

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mobile). Data and results of test of a compound portable engine using superheated steam. 2500 w. Zeitschr d Ver Deutscher Ing—July 27, 1901. No. 42824 D.

Scale.

The Chemistry of Deposits in Steam Boilers. W. E. Ridenour. Considers the physical appearance and vast amount of these accumulations, and discusses the chemical salts existing in these deposits. 1200 w. Jour Fr Inst—Aug., 1901. No. 42488 D.

Smoke.

Smoky Furnaces and How to Avoid Them. W. H. Booth. The first of a series of articles proposing to deal with a few furnaces in use, with a view to showing how far they are constructed upon correct lines and in what points they may fail to effect perfect combustion. 2400 w. Elec Rev, Lond—July 25, 1901. Serial. 1st part. No. 42521 A.

Steam.

Power Steam. D. B. Dixon. On the nature and properties of steam. 2500 w Mod Mach—Aug., 1901. No. 42565.

Steam Engines.

How to increase the Horse-Power of a Steam Engine. D. B. Dixon. Discusses ways in which the horse-power can be increased. 1800 w. Am Mfr—Aug. 8, 1901. No. 42637.

The Experimental Study of the Steam Engine. John T. Nicholson. Lecture before the Engng Soc of the Owens College Union. 4000 w. Prac Engr—Aug 2, 1901. Serial. 1st part. No. 42640 A.

Steam Heating.

Steam Heat with Condensing Engines. Alton D. Adams. Discusses the use of the vacuum system of heating with steam from condensing engines and the work which may be done by exhaust steam. 1300 w. Sci Am—Aug. 24, 1901. No. 42772.

Valve Motion.

Valve Motion of Recent Passenger Locomotives. Gives a diagram of the valve motion of the "Central Atlantic" type locomotives, and calls attention to the remarkable uniformity of cut-off. 400 w. Am Engr & R R Jour—Aug., 1901. No. 42499 C.

Valves.

Throttle Valves for Steam Engines. W. H. Wakeman. Showing the advantages and disadvantages of some familiar types. Ill. 900 w. Engr, U. S. A.—Aug. 1, 1901. No. 42498.

MISCELLANY.

Aeronautics.

Motor Ballooning. Illustrates the apparatus of M. Santos-Dumont giving particulars of the mechanism and remarks on other machines by the same inventor. 1600 w. Autocar—July 27, 1901. No. 42513 A.

The Empire of the Air. Gives an illustrated description of the air ship used by M. Dumont in his last attempt to secure the Deutsch prize, with a review of the types of machines most likely to solve this problem. 2700 w. Auto Jour—Aug., 1901. No. 42930 A.

The Motor Balloonist's Escape. Concerning the accident to M. Santos-Dumont's air ship. 700 w. Autocar—Aug. 17, 1901. No. 42927 A.

The Santos-Dumont Navigable Balloon. An illustrated account of the work of M. Santos-Dumont in this field. 2500 w. Engr, Lond—July 26, 1901. No. 42530 A.

Ballistics.

The Law of Pressures in Guns (Sur la Loi des Pressions dans les Bonches à Feu). E. Vallier. An extension of the author's previous researches upon the relations of pressure and projectile velocity. 1200 w. Comptes Rendus—July 22, 1901. No. 42837 D.

Education.

A Founders' Trade School. Thomas D. West. Shows need of such a school because of the advancement in the art of founding; outlines the kind of school required and suggests the means of obtaining it. 1500 w. Ir Trd Rev—July 25, 1901. No. 42436.

Exhibitions.

Engineering at the Glasgow Exhibition. John G. Kerr. A finely illustrated article describing salient points in the steam plant and machinery section, and showing improvements of great importance. 3300 w. Engineering Magazine—Sept., 1901. No. 42899 B.

Mechanical and Electrical Features of the Pan-American Exposition. William S. Aldrich. Illustrates and describes the important appliances displayed, calling attention to the tendencies in recent development. 4800 w. Engineering Magazine—Sept., 1901. No. 42898 B.

The Engineering Organization of a Great Exposition. Georges Caye. Considers the services rendered by the engineering profession in the organization and administration of the Paris Exposition. Fully illustrated. 4000 w. Engineering Magazine. Sept., 1901. No. 42897 B.

Foreign Shipment.

Boxing Machine Tools for Foreign Shipment. J. M. Richardson. Considers some of the requirements in packing machinery to send abroad. 1800 w. Am Mach—Aug. 15, 1901. No. 42698.

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Guns.

Modern Guns at the Pan-American Exposition. Grahame H. Powell. Illustrated description of the exhibit of guns used in the coast defense of the United States. 1800 w. Am Mach—Aug. 1, 1901. No. 42457.

Naval Ordnance. A. Trevor Dawson. Considers the structure of guns, the breech mechanism, the motive power for working large guns within turrets, mountings, guns to repel torpedo and submarine boat attack, projectiles, &c. 33 plates. 18300 w. Inst Mech Engrs—Aug., 1901. No. 42590 D.

The 16-Inch Breech-Loading Rifle. Waldon Fawcett. Illustrated account of this gun and its construction. 1700 w. Am Mfr—Aug. 1, 1901. No. 42563.

Handling.

Moving a Cylinder. Illustrated directions for loading and unloading on cars or wagons. 2000 w. Power—Aug., 1901. No. 42453.

Invention.

A Century of American Invention. Leon Mead. Reviews the history of the patent system, pointing out the manner in which certain inventions have increased the world's commerce, added to the comfort of the human family, and enlarged the opportunities of labor. 3000 w. Gunton's Mag—Aug., 1901. No. 42486 C.

Oxygen.

Industrial Oxygen (L'Oxygen Industriel). Raoul Pictet. Describing an improved method for obtaining pure oxygen at a cost lower than that of common illuminating gas by fractional distillation of liquid air. The liquid air supply is continually replaced by the process. An important paper. 6000 w. Mem Soc Ing Civ de France—June, 1901. No. 42817 G.

Pyrometry.

A System of Corrections for Heat Losses in Calorimetric Experiments. Joseph W. Richards. Describes systems of corrections which have been used several years and given accurate and satisfactory results. 2300 w. Jour Fr Inst—Aug., 1901. No. 42487 D.

The Measurement of High Temperatures. S. Geijsbeek. Begins an outline of the principal apparatus in use and a review of the methods employed. Ill. 1100 w. Min Rept—Aug. 8, 1901. Serial. 1st part. No. 42630.

Sugar Machinery.

Notes on Erecting Sugar Machinery. From *Steam Engineering.* Describes the methods employed in building the foundations and erecting the apparatus. Ill. 1700 w. Mach, N. Y.—Aug., 1901. No. 42451.

MINING AND METALLURGY

COAL AND COKE.

Accidents.

Fatal Accidents in Coal Mining in North America. Frederick L. Hoffman. Comparative statistics covering the last decade, showing the fatalities in 1900 to be greater than in any other year. 1200 w. Eng & Min Jour—Aug. 10, 1901. No. 42598.

Alabama.

The Mineral District of Alabama. An illustrated article reviewing its resources in iron and coal. 5500 w. Ir & Coal Trds Rev—Aug. 9, 1901. No. 42740 A.

Balance Platform.

Notes on a Briart Balance Platform Installed at Shaft No. 6 at Gorlooka, South Russia. A. Lebrun. Illustrated description of the apparatus with a statement of its advantages. 1200 w. Ir & Coal Trds Rev—Aug. 16, 1901. No. 42948 A.

Coal-Fields.

The Allegheny Valley Coal-Fields. William Gilbert Irwin. Concerning these productive fields as recently developed. 1200 w. Eng & Min Jour—Aug. 24, 1901. No. 42790.

Coals.

See Gas Works Engineering.

Dredging.

Dredging for Coal. An illustrated description of the method of mining in the Mission Field Coal Mine, Illinois, by the use of the steam shovel cableway. 1500 w. Mines & Min—Aug., 1901. No. 42621 C.

Haulage.

A Lancashire Electrical Haulage Plant. Illustrates and describes a plant at Breightmet Colliery, near Bolton, as a type of the ease with which electricity may be applied to mining machinery. 800 w. Col Guard—July 26, 1901. No. 42523 A.

India.

Indian Coal. Editorial discussion of the opening of coal mines in different parts of India, because of the high price of English coal. 1200 w. Engng—Aug. 16, 1901. No. 42958 A.

Machine Cutting.

Coal Cutting by Machinery. Ernest Kilburn Scott. Contributed to the Inst. of Civ. Engrs. Reviews the history of

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mechanical coal cutting, giving illustrated descriptions of the various types of machines, and discussing the process used. 6500 w. Ir & Coal Trds Rev—Aug. 16, 1901. No. 42945 A.

Nineteenth Century.

Coal Mining in the Nineteenth Century. W. Blakemore. Read before the Applied Science Society of McGill Univ. Gives statistics of production, discussing the remarkable development, economic considerations, effect on transportation, improved methods, &c., referring especially to Canada. 7500 w. Can Engr—Aug., 1901. No. 42566.

Ohio Coal.

The Economic Value of the Clarion Coal in Vinton and Jackson Counties, Ohio. N. W. Lord. Abstract of a paper read before the Ohio Inst. of Min. Engrs. Describes tests made of these coals, and gives results. 1400 w. Eng News—Aug. 22, 1901. No. 42908.

Production.

The Coal Production of the Principal Countries of the World. Statistics from the report of the British Board of Trade. 2700 w. Col Guard—July 26, 1901. No. 42522 A.

Screening and Washing.

New Coal-Screening and Washing Plant at a Belgian Colliery. J. de Jaer. From *the Annals des Mines de Belgique*. Illustrated description. 800 w. Col Guard—Aug. 16, 1901. No. 42956 A.

Trans-Mississippi Coals.

The Stratigraphical Location of Named Trans-Mississippian Coals. Charles R. Keys. Gives the original localities. 1200 w. Eng & Min Jour—Aug. 17, 1901. No. 42707.

Workings.

A Modified Longwall System. Clarence R. Claghorn. Read before the Cen. Min. Inst. of W. Penn. Illustrated notes on the method employed at the Vintondale mine of the Vinton Colliery Company. 3500 w. Mines & Min—Aug., 1901. No. 42624 C.

COPPER.

Arizona.

The Verde Mining District, Arizona. John Jewett. Reviews the situation and prospects of the copper mines of this district. Ill. 2000 w. Eng & Min Jour—Aug. 10, 1901. No. 42600.

Concentration.

Comparison of Fire with Water for Concentration. S. E. Bretherton. Claims that in copper smelting the "fire process" is driving the wet concentration process to handle only extremely siliceous ores low in values. 1200 w. Min & Sci Pr—Aug. 24, 1901. No. 42961.

Ore Treatment.

Treatment of Low-Grade Copper Ores. An account of the Doetsch process used at the Rio Tinto mines in Spain. 900 w. Min Rept—Aug. 1, 1901. No. 42537.

Refining.

Electric Copper Refining. George E. Walsh. On the processes employed and the further preparation for commercial purposes. 1800 w. Elec Rev, N. Y.—Aug. 24, 1901. No. 42785.

GOLD AND SILVER.

Alaska.

Mining along the Alaska Coast—Ketchikan, Alaska—The Atlin Country. W. M. Brewer. An account of a recent visit to these regions, with reports of the mining conditions. 3500 w. Eng & Min Jour—Aug. 24, 1901. No. 42792.

Dominion Assay Office in Vancouver. Alfred W. Dyer. Describes the office and the process; the operations are conducted in full view of the depositor of gold dust. 2300 w. B. C. Min Rec—Aug., 1901. No. 42658 B.

Beach Sands.

Auriferous Beach Sands of British Columbia. General information concerning these deposits and the attempts to work them, the machines used, &c. Ill. 5000 w. B. C. Min Rec—Aug., 1901. No. 42659 B.

Cyaniding.

Cyaniding Cupriferous Ores. L. Janin, Jr. Describes the treatment of these ores in the Transvaal. It depends upon the property of cupro-cyanide of potassium to dissolve a small quantity of copper in the form of sub-cyanide, which is then precipitated. 1100 w. Eng & Min Jour—Aug. 17, 1901. No. 42706.

Extraction.

Electrolytic Gold Extraction. An illustrated description of the Reicken process, describing the apparatus. 2500 w. Aust Min Stand—July 18, 1901. Serial. 1st part. No. 42729 B.

Fine Gold.

Method of Saving Fine Gold of Snake River, Idaho. William H. Washburn. Gives a brief description of some of the methods which have led to the processes now most successfully used. 2500 w. Min & Sci Pr—Aug. 3, 1901. No. 42575.

India.

The Kolar Gold Fields. Reviews the history of gold recovery in India. The first article is introductory. 2500 w. Ind & East Engr—July, 1901. Serial. 1st part. No. 42716 B.

Nineteenth Century.

The Gold Standard and the Gold Pro-

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duction in the Nineteenth Century. Horace White. Concerning the adoption of the single gold standard by the most important countries of the civilized world; the production, discoveries, &c. 1800 w. W. Min Wld—Aug. 3, 1901. No. 42569.

Siberia.

The Gold Mines of Siberia. Chester Wells Purington. Illustrated description of the primitive methods used in what promises to be an exceedingly rich region. 2400 w. Engineering Magazine—Sept., 1901. No. 42894 B.

Stamp Mills.

Stamp Mill Construction. J. J. Deming. Discusses the inprovement made and the important principles of good construction. 4000 w. W. Min Wld—Aug. 17, 1901. No. 42741.

Sulphides.

The Sulphide Ore Problem. Jas. W. Worsey. Begins a discussion of the systems of treatment used with zinciferous lead sulphides. 900 w. Min & Sci Pr—Aug. 3, 1901. Serial. 1st part. No. 42574.

Tasmania.

North Mount Farrell Silver-Lead Mine. An illustrated account of the discovery and development. 1800 w. Aust Min Stand—June 27, 1901. No. 42664 B.

IRON AND STEEL.

Angle Rolls.

See Mechanical Engineering, Machine Works and Foundries.

Blast Stoves.

Brick Blast-Heating Stoves (Steinerne Winderhitzer). F. W. Lürmann. A discussion of the construction, the behaviour of bricks used in the checkerwork of hot blast stoves with data of tests, showing the importance of using high-grade material. 3500 w. Stahl und Eisen—Aug. 1, 1901. No. 42838 D.

Casting Machine.

Pig Iron Casting Machines (Roheisen Giessmaschinen). E. Belain. A description of the Ramsey machine, which differs from that of Uehling in having the moulds on the periphery of a large wheel, instead of being carried on a chain gear. 1200 w. Stahl und Eisen—Aug. 15, 1901. No. 42843 D.

Compression.

The Compression of Steel (Dichten des Stahls). A. W. Zdanowicz. A description of the hydraulic machinery for compressing steel ingots, as used at the St. Etienne works in France. 3500 w. Stahl und Eisen—Aug. 15, 1901. No. 42844 D.

Furnaces.

Open-Hearth Steel Melting Furnaces. Brief illustrated description of the Wellman rolling open-hearth furnaces. 900 w. Sci Am Sup—Aug. 3, 1901. No. 42477.

Iron Smelting.

Iron Smelting at Nowa Nowa, (V.). Henry C. Jenkins. From the report of the government metallurgist, giving information concerning conditions and cost. 1500 w. Aust Min Stand—July 4, 1901. Serial. 1st part. No. 42665 B.

Japan.

Japanese Iron Works (Ueber den Japanischen Eisenhüttenbetrieb). A. Ledebur. With illustrations of mines, furnaces and primitive equipment. 2500 w. Stahl und Eisen—Aug. 15, 1901. No. 42842 D.

Phase Theory.

Iron and Steel from the Standpoint of the Phase Theory (Eisen und Stahl vom Standpunkte der Phasenlehr). H. von Jüptner. A review of the theory of Roozeboom, with reference to the criticisms of Osmond and Le Chatelier. 2500 w. Stahl und Eisen—Aug. 1, 1901. No. 42839 D.

Rail Steel.

Rail Steel. With Especial Reference to Its Hardness. Sectional discussion from the *Bulletin* of the International, Ry., Cong., summarizing the reports on the "Nature of Metals for Rails," and giving views of eminent authorities. 5300 w. R R Gaz—Aug. 23, 1901. No. 42914.

Separating.

Magnetic Ore Separating at Pitkäranta in Finland (Die Magnetische Erzaufbereitung zu Pitkäranta in Finland). G. Gröndal. A description of the use of the author's magnetic separator with the magnetic ores of Finland. 1800 w. Oesterr Zeitschr f Berg u Hüttenwesen—Aug. 10, 1901. No. 42857 B.

Spain.

Notes on the Iron Ore Deposits of Bilbao, Northern Spain. Frank D. Adams. Read before the Applied Science Society of McGill Univ. Information concerning these deposits, their value, the workings, &c. 2800 w. Can Engr—Aug., 1901. No. 42567.

Tropenas Process.

The Tropenas Converter Steel Process. A. Tropenas. Illustrated description of the process with information concerning it. 3200 w. Jour Am Found Assn—Sept., 1901. No. 42960.

MINING.

Accounts.

Mine Account Keeping and the Monthly Statement of Costs, as adapted to the Business of Metalliferous Mining. Charles V. Jenkins. Describes a thorough system of bookkeeping showing its value.

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10300 w. Mines & Min—Aug., 1901. No. 42622 C.

Boring.

Boring for Natural Inflammable Gas, Oil, &c. Illustrates modern tools and describes methods. 1300 w. Am Gas Lgt Jour—Aug. 5, 1901. No. 42552.

British Columbia.

Mining in British Columbia. E. Jacobs. Review of this important industry, especially the development during the last ten years. 3000 w. B C Min Rec—Aug., 1901. No. 42660 B.

Colorado.

Twenty-five years' Progress in Colorado. Thomas F. Walsh. Address at a banquet at Colorado Springs. A summary of the mineral development of that State and the general progress. 2000 w. Min Rept—Aug. 8, 1901. No. 42629.

Electric Hoists.

See Electrical Engineering, Power Applications.

Explosion.

Official Report on the Blaendare Explosion. Presents reports by S. T. Evans and Joseph S. Martin on the circumstances attending the explosion by firedamp, which occurred on Feb. 28, 1901. Ill. 3000 w. Col Guard—Aug. 2, 1901. No. 42655 A.

Explosives.

Explosives in Coal Mines. Considers British legislation and the "permitted list" of explosives, discussing who should be held responsible in case of accident with these explosives. 1700 w. Col Guard—Aug. 2, 1901. No. 42653 A.

Practical Means of Testing Explosives. P. Chalon. Abstracts from an article in the *Revue Technique*. Reviews the behavior of explosives and methods of testing to determine their strength. 1400 w. Min Rept—Aug. 15, 1901. No. 42703.

Exposition.

The Pan-American Exposition. A general description of the grounds, etc., with special reference to the mining and engineering exhibits. Ill. 4800 w. Mines & Min—Aug., 1901. No. 42626 C.

Fans.

Description of, and Experiments with, M. Guibal's Fan. John W. Robinson. From the *Jour. of the Brit. Soc. of Min. Students*. 1800 w. Ir & Coal Trds Rev—Aug. 16, 1901. No. 42947 A.

Faults.

Faults.—Displacements. J. P. Wallace. Explains the occurrence of faults, and gives rules for recovering faulted veins. 1600 w. Min Rept—Aug. 22, 1901. No. 42787.

Firedamp.

The Firedamp Explosion in the Pluto Shaft at Wiesa (Die Schlagwetter Explosionen auf den Pluto schächten in Wiesa). F. Okorn. Abstract of the official report upon the fatal explosion of Nov. 13, 1900. Serial. Part 1. 1500 w. Two plates. Oesterr Zeitschr f Berg u Hüttenwesen—July 20, 1901. No. 42856 B.

Lodes.

The Pennsylvania M. Co. vs. Grass Valley Exploration Co., Litigation. Gives views of models used in this legal contest, showing interesting phenomena of lode occurrence, with explanation. 1000 w. Min & Sci Pr—Aug. 3, 1901. No. 42573.

Mexico.

Mexico's Progress in Mining Matters. William M. Courtis. Illustrates and describes a rich region that is being opened, the difficulties of transportation, and some of the work accomplished. 3200 w. Mines & Min—Aug., 1901. No. 42620 C.

Mine Cars.

Steel Mine Cars. M. G. Moore. Illustrates forms of construction and gives comparison of weights of steel cars with wooden cars of like capacities. 2000 w. Mines & Min—Aug., 1901. No. 42623 C.

Mining Plant.

See Electrical Engineering, Power Applications.

New Guinea.

Mining at Woodlark Island. M. Lobel. An account of this portion of British New Guinea, reporting great mineral resources, but a very trying climate. 2500 w. Aust Min Stand—July 18, 1901. No. 42727 B.

Ontario.

Mining in Eastern Ontario. Courtenay De Kalb. A review of the condition of the mining industry, reporting the conditions of various mining properties. 6000 w. Can Min Rev—July 31. 1901. No. 42505 B.

Mining in Ontario. Information from the annual report of the bureau of mines of Ontario, showing the great advancement made during the last few years, the output, value, &c. 1100 w. U. S. Cons Repts. No. 1119—Aug. 21, 1901. No. 42738 D.

Pumping.

See Electrical Engineering, Power Applications.

Safety Catches.

The Theory of Safety Catches (Theorie der Fangvorrichtungen). R. A. Henry. A discussion of the action of safety catches on mine hoists, showing their application to an improved construction in connection with a hydraulic brake. Two articles, 7500 w. Two plates. Glückauf—Aug. 3, 10, 1901. No. 42855 each B.

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Shaft Sinking.

High Speed Rotary Hydraulic Shaft-Boring Machine. G. Schneiders, in *Glückauf*. Illustrated description of the machine and its operation. 1100 w. Col Guard—Aug. 2, 1901. No. 42654 A.

The Future of Shaft Sinking (Zukunft und Zeile der Schachtbohrtechnik). G. Schneiders. Discussing the Kind-Chandron system and also an improved system with hydraulic removal of material. 5000 w. Two plates. Glückauf—July 27, 1901. No. 42854 B.

Veins.

Vein Definition. A summary of the definitions and opinions submitted by Ross E. Browne in the course of testimony in a recent trial. Ill. 4000 w. Min & Sci Pr—Aug. 17, 1901. No. 42743.

Well Boring.

Well Boring Machinery in Australia. W. Gibbons Cox. Treats of the machinery and apparatus now used, briefly reviewing the development. 3400 w. Engr Lond—Aug. 9, 1901. No. 42735 A.

Winding.

Enclosing a Ventilating Shaft for Winding Purposes. Illustrates and describes the arrangements at Neumühl Colliery to prevent waste of air during the operation of winding. 600 w. Col Guard—Aug. 9, 1901. No. 42739 A.

Wide Lodes.

Some Methods of Limbering and Working Wide Lodes in New South Wales. J. R. Godfrey. Abstract of paper read before the Australian Min. Engrs. An illustrated study of cases of actual mining when local conditions require special methods. 2300 w. Eng & Min Jour—Aug. 17, 1901. Serial. 1st part. No. 42708

MISCELLANY.

Abuse of Coal.

The Use and Abuse of Coal. Discusses coal as a fuel for brick burning in particular. 3300 w. Brick—Aug., 1901. No. 42561.

Analysis.

The Determination of Arsenic, Antimony, Tin and Bismuth in Fine Lead. M. Liebschutz. Describes method in detail. 1000 w. Eng & Min Jour—Aug. 10, 1901. No. 42599.

Aluminothermy.

Metals as Fuel. Sir W. Roberts-Austen. Abstract of a discourse delivered at the Royal Inst. Shows that metals may be burnt for the sake of the heat and light they produce. Ill. 5200 w. Nature—Aug. 8, 1901. No. 42722

Antimony.

The West Gore Antimony Deposits. W. R. Askwith. Brief description of the deposits in Nova Scotia. Ill. 1600 w. Can Min Rev—July 31, 1901. No. 42503 B.

Cadmium.

The Quantitative Determination of Cadmium. Edmund H. Miller and Robert W. Page. Describes work on a solution of cadmium chloride. The methods compared are the electrolytic, the carbonate and the phosphate. 2000 w. Sch of Mines Qr—July, 1901. No. 42744 D.

Coal-Tar.

Derivatives of Coal Tar. Condensed from the *Revue Technique*. An account of the distillation, refining and laboratory work. 5500 w. Pro Age—Aug. 15, 1901. No. 42671.

Corundum.

Corundum Deposits of Canada. Information concerning valuable and easily worked deposits recently discovered. 300 w. U. S. Cons Repts, No. 1102—Aug. 1, 1901. No. 42470 D.

Diamonds.

Diamonds in New South Wales. Information concerning the diamond fields, the stones found, etc. 500 w. U. S. Cons Repts, No. 1102—Aug. 1, 1901. No. 42469 D.

Metallurgical Fuels.

Present Day Metallurgical Fuels. Percy Longmuir. Deals with fuels of industrial interests both natural and artificial. 2500 w. Ir Trd Rev—Aug. 22, 1901. No. 42764.

Petroleum.

Petroleum—Something of Its History. James W. Drape, in *Stowell's Petroleum Reporter*. An interesting historical review. 2500 w. Am Gas Lgt Jour—Aug. 5, 1901. No. 42554.

The Present Condition of the Petroleum Industry in California. W. G. Young. A general summary of present conditions of these large deposits. 1500 w. Eng & Min Jour—Aug. 24, 1901. No. 42791.

Potters Clay.

Potters Clay at Middle Musquodoboit. F. H. Mason. Read before the Min Soc. of Nova Scotia. Describes the deposits and tests made. 1000 w. Can Min Rev—July 31, 1901. No. 42504 B.

Sapphires.

Sapphire Mining, Yogo, Montana. An illustrated description of these valuable deposits and the methods of mining. 1400 w. Min & Sci Pr—July 27, 1901. No. 42464.

Sweden.

See Industrial Economics.

Tariff.

See Industrial Economics.

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RAILWAYS AND TRAMWAYS.

CONDUCTING TRANSPORTATION.

Accidents.

Train Accidents in the United States in June. Detailed list and classified summary; 211 accidents in which 67 persons were killed and 241 injured. 4500 w. R R Gaz —Aug. 2, 1901. No. 42511.

Dispatching.

Two Methods of Dispatching on Interurban Electric Railways. Describes two methods quite different in principle, one used by the Union Traction Co. of Indiana, and the other by the Toledo, Fremont & Norwalk R. R. Ill. 2800 w.St Ry Rev—Aug. 15, 1901. No. 42715 C.

Transferring Freight.

Transferring Grain from Boats to Cars at Hickman, Ky. Abstract of an article by C. B. Wilson, contributed to the Trans. of the Engng Assn. of the South, showing one of the methods used for transporting freight from river steamers to the railways. Ill. 1000 w. Eng News—Aug. 1, 1901. No. 42483.

MOTIVE POWER AND EQUIPMENT.

Acetylene.

See Gas Works Engineering.

Alpine Road.

The Davos—Schatzalp Railway (Die Davos-Platz—Schatzalp Bahn). C. Wetzel. Describing the electrically operated cable road from Davos, Switzerland, to the sanitarium on the Schatzalp, 300 metres above. Serial. Part 1. 1000 w. Schweizerische Bauzeitung—Aug. 17, 1901. No. 42852 B.

Baltimore, Md.

The Street Railway System of Baltimore. An illustrated account of important changes and additions which have greatly improved the system. 5000 w. St Ry Rev—Aug. 15, 1901. No. 42713 C.

Berlin.

High Speed Electric Traction at Berlin. A concise statement of what has been undertaken at Berlin by the experimenters in this field, what has been accomplished, and what remains to be done. 900 w. U. S. Cons. Repts, No. 1103—Aug. 2, 1901. No. 42471 D.

Boiler Explosion.

The Knottingley Boiler Explosion. An account of the explosion of a new locomotive on the Lancashire and Yorkshire Railway, on the 11th of last March, with editorial. 6300 w. Ill. Engr. Lond—Aug. 9, 1901. No. 42737 A.

Boston Elevated.

Operating Features of the Boston Elevated. Francis H. Shepard. An illustrated article calling attention to interesting features of operation. 3000 w. Elec Wld & Engr—Aug. 10, 1901. No. 42627.

Brake Shoes.

The M. C. B. Brake-Shoe Tests. F. W. Sargent. Diagrams giving records of tests arranged with the speed constant and the loads varying, with discussion of points of interest. 2400 w. R R Gaz—Aug. 9, 1901. No. 42609.

Caboose.

A Chesapeake & Ohio Standard Caboose. Illustrated description of a design especially adapted to the needs of this road. 800 w. Ry Age—Aug. 9, 1901. No. 42661.

Cars.

80,000 Lbs. Capacity Drop Bottom Coal Car—Pittsburgh Coal Co. Illustrated description of a design from which 500 cars are being built. 1000 w. R R Gaz—Aug. 23, 1901. No. 42915.

50-Ton Twin-Hopper Car with Rolled Steel Underframe—Northern Pacific. Illustrated description. 700 w. R R Gaz—Aug. 9, 1901. No. 42612.

Low-Side Gondola Car for the Union Steel Company. Drawings and description with data from the calculations of stresses. 500 w. R R Gaz—Aug. 2, 1901. No. 42508.

Cleaning.

Proper Method of Cleaning Brake Cylinders and Triple Valves of Freight Cars. Otto Best. Directions for the cleaning and testing of triple valves and cylinders. Ill. 4400 w. Ry & Engng Rev—Aug. 24, 1901. No. 42794.

Controllers.

Traction Controllers (Zugsteuerungen). M. Kubierschky. A description of a system of controlling a number of motor cars from one controller on the Sprague principle, this being by the Union Electric Works of Berlin. 4000 w. Elektrotech Zeitschr—July 11, 1901. No. 42862 B.

Coupling.

The Conversion of the European Screw-Coupling into the American Coupling (Die Umwandlung der Europäischen Schraubenkuppelung in die Amerikanische Mittelbuffer-Kuppelung). J. Grimme. Illustrating an arrangement by which hooks of the Janney type are combined with the screw form, to aid in the transition. 1500 w. Glasers Annalen—Aug. 15, 1901. No. 42832 D.

Driver Brakes.

An Automatic Pressure Retainer for Driver Brakes. J. E. Muhlfeld. Drawings and description of a device in use

on the Grand Trunk Ry., with a statement of its advantages. 1200 w. R R Gaz—Aug. 16, 1901. No. 42681.

Dublin.

The Dublin United Tramway System. A detailed account of the present condition and gradual development. Ill. 1800 w. Elect'n, Lond—Aug. 9, 1901. Serial. 1st part. No. 42724 A.

East Ham.

East Ham Electric Tramways and Lighting Installation. Illustrated detailed description of the first municipal electric tramway system in the Metropolitan district of London. 2500 w. Tram & Ry Wld—July 11, 1901. No. 42534 B.

Electric Traction.

High-Speed Electric Traction Between Milan and the Italian Lakes. Illustrates and describes the line, its operation, the steam generating plant, sub-stations, rolling stock, &c. 3800 w. St Ry Jour—Aug. 3, 1901. No. 42550 D.

Electricity vs. Steam.

The Supersession of the Steam Locomotive. W. E. Warrilow. Discusses the scheme proposed by Mr. Langdon in his paper "The Supersession of the Steam by the Electric Locomotive," and does not favor the conversion of the steam railway to the electric. 2800 w. Elec Engr, Lond—Aug. 16, 1901. No. 42935 A.

Electric Locomotive.

The Electric Locomotives of the Orleans Railway (Locomotives Electriques de la Compagnie des Chemins de Fer d'Orleans). An illustrated description of the locomotives for hauling the trains on the new extension of the Orleans railway in Paris. 1800 w. Revue Technique—July 10, 1901. No. 42810 D.

Electric Railways.

Wide and Narrow Gauge Electric Railways (Ueber Elektrische Vollund Schnellbahnen). Max Schiemann. A discussion of the problem of the application of electric driving to main line railways, in view of what has already been accomplished in tramways. 4500 w. Elektrotech Zeitschr—July 25, 1901. No. 42868 B.

Headlights.

Electric Headlights. An explanation of the care and management of these lights. 1500 w. Loc Engng—Aug., 1901. No. 42445 C.

Hubs.

Strength of Cast Iron Hubs. George L. Fowler. A report of experimental investigations to determine the bursting strength of some cast-iron hubs to be used in railroad service, where it was desired to use the thinnest metal possible. 2700 w. Ry Age—Aug. 23, 1901. No. 42780.

Indicator.

A Simple Locomotive Engine Indicator. Illustrated description of a device of considerable value, invented by Eric Norden. 350 w. Sci Am—Aug. 24, 1901. No. 42770.

Italy.

Heavy Electric Traction in the North of Italy. Enrico Bignami. Illustrated account of the projects under way and experiments in progress. 1200 w. Elec Rev, N. Y.—Aug. 10, 1901. No. 42597.

Locomotives.

American Locomotives and Foreign Buyers. S. R. Calloway. Reprint from the *Saturday Evening Post* of Philadelphia. On the recent criticisms of American locomotives sent to England. 3000 w. Ry & Engng Rev—Aug. 10, 1901. No. 42663.

Compound Express Engine, Hungarian State Railways. Illustrated detailed description of an engine exhibited at Paris, which possesses novel features. 1800 w. Engr, Lond—Aug. 9, 1901. No. 42736 A.

Coupled Express Engines on the Great Western Railway. Charles Rous-Marten. Explains the origin of the Atbara class of engines, and also discusses the Badminton and Camel classes. Reports concerning their operation. Ill. 2000 w. Engr, Lond—Aug. 2, 1901. No. 42649 A.

Explosions of Historical Locomotives. Reviews explosions of interest since the earliest use of locomotives. 1500 w. Engr, Lond—Aug. 2, 1901. No. 42650 A.

Freight Locomotive for Heavy Grades. Illustration and description of an engine of the Canadian Pacific R. R., of great tractive power, successfully used on grades of exceptional severity. 700 w. Sci Am—Aug. 24, 1901. No. 42769.

Inspection Locomotive—Chicago, Burlington and Quincy Railroad. Brief illustrated description. 300 w. Am Engr & R R Jour—Aug., 1901. No. 42500 C.

The Newest Six-Coupled Express Engines on the North-Eastern Railway. Charles Rous-Marten. Describes the new engine No. 2111 and gives a report of work accomplished by it. 3000 w. Engr, Lond—July 26, 1901. No. 42528 A.

The Tractive Power of Locomotives. W. F. M. Goss. Offered in discussion of a paper by G. R. Henderson on "A Practical Tonnage Rating," at the Mas. Mech's Con., June, 1901. 700 w. R R Gaz—Aug. 16, 1901. No. 42677.

London Tramways.

The Electric Trolley Lines of London. Illustrates and describes the model power house, showing the latest tramway work in England. 3800 w. Elec, N. Y.—Aug. 14, 1901. No. 42666.

Newcastle-on-Tyne.

Neptune Bank Power Station at New-

We supply copies of these articles. See page 159.

castle-on-Tyne. Illustrated detailed description of a station designed to supply electric energy for industrial purposes, lighting and traction. 5300 w. Tram & Ry Wld—July 11, 1901. No. 42535 B.

Open Cars.

New Style Open Cars in Montreal. Brief illustrated description of a novel type having one side open and the other closed. 700 w. St Ry Rev—Aug. 15, 1901. No. 42714 C.

Paris.

The Paris Metropolitan Railway (Le Métropolitain de Paris). A. Dumas. A review of the experience with the section now in operation and a description of the portions projected and under construction. The new carriages are shown. 2000 w. Génie Civil—July 20, 1901. No. 42801 D.

Railway Plant.

The Electric Plant of the Orleans Railway (Installations Electriques de la Compagnie des Chemins de Fer d'Orleans). A general description of the generating station for the operation of the electric section between the Pont d'Austerlitz and the Quai d' Orsay, Paris. 2500 w. Revue Technique—Aug. 10, 1901. No. 42807 D.

Rolling Stock.

Rhodesian Railway Rolling Stock. Illustrates typical cars, giving brief description. 500 w. Engng—Aug. 9, 1901. No. 42732 A.

Switzerland.

Electrical Distribution of the Bex-Gryon-Villars Railway (Distribution d'Energie Electrique et Chemin de Fer de Bex-Gryon-Villars). K. A. Breuer. With a description of the Sublin hydro-electric station of 1600 h. p., and the distribution of current for traction and power among villages in the Rhone valley. Serial. Part I. 3000 w. 1 plate. Génie Civil—Aug. 10, 1901. No. 42803 D.

Tramway Line.

The Holland-Friesland Line and the Lemmer-Joure Steam Tramway (De Holland-Friesland-Lijn en de Stoomtram Lemmer-Joure). With description of the steamboats and dock at Lemmer, and an account of the opening of the new tramway line. 3000 w. De Ingenieur—Aug. 17, 1901. No. 42850 D.

Underground.

The Electrical Equipment of the District and Metropolitan Railways. Charles T. Yerkes. Letter to the London *Times* explaining the position of the company represented by the writer. 1500 w. Elect'n, Lond—Aug. 2, 1901. No. 42643 A.

Underground Railways in London. Report from the Joint Select Committee of the House of Lords and House of Commons, recently issued. 3000 w. Archt, Lond—Aug. 2, 1901. No. 42639 A.

Unloading Rails.

Unloading Rails, Chicago, Milwaukee & St. Paul Ry. Illustrated description of the method used on this road. 900 w. Ry Engng Rev—Aug. 24, 1901. No. 42795.

Valteline.

The Valteline Electric Railway (Le Chemin de Fer Electrique de la Valteline). A general description of the application of three-phase electric traction to 106 kilometres of main railway between Lecco and Sondrio, Italy. The Ganz system is employed. 2000 w. Revue Technique—Aug. 10, 1901. No. 42808 D.

Valve Motion.

Locomotive Valve Motion. S. J. Dillon. Abstract of a talk given to engineers and firemen of the Pennsylvania Railroad. 800 w. Loc Engng—Aug., 1901. Serial. 1st part. No. 42444 C.

PERMANENT WAY AND FIXTURES.

Ballasting.

Ballasting New Railways. Abstract of an article by J. C. Rockhold, in the *Roadmaster and Foreman*. Advocates ballasting with plenty of good earth until the roadbed has become consolidated enough for permanent ballast. 1300 w. Eng News—Aug. 22, 1901. No. 42910.

Car House.

A New Car House for Brooklyn of Novel Design. Illustrates and describes the proposed structure. 800 w. St Ry Jour—Aug. 3, 1901. No. 42548 D.

Construction.

Methods of Safety for the Overhead Electric Trolley System. Edward Manville. Read before the Incor. Assn. of Munic. & Co. Engrs. Considers the precautions to be taken to ensure solid construction and methods of ensuring safety should a breakdown occur. Ill. 3800 w. Tram & Ry Wld—July 11, 1901. No. 42536 B.

Crossings.

The Abolition of Railroad Crossings at Grade. From the report of L. M. Hastings, offering plans for solving the various problems arising and making his recommendations. Ills. 2200 w. Munic Engng—Aug., 1901. No. 42558 C.

Electric Incline.

Palermo-Monreale Electric Incline. Illustrated description of this recently completed and novel road. 1200 w. Sci Am —Aug. 31, 1901. No. 42969.

India.

The Shortening of the Main Routes in India. Stafford Ransome. Concerning changes to be made on the Calcutta and Bombay route. Ill. 500 w. Engr, Lond —Aug. 16, 1901. No. 42953 A.

We supply copies of these articles. See page 159.

Interlocking.

Pneumatic Interlocking on the London and Southwestern. Diagram and locking sheet showing the scheme of a signaling plant lately put in service at Grateley, 72 miles from London. 700 w. R R Gaz—Aug. 16, 1901. No. 42679.

Interurban.

The Interurban Electric Railways of Ohio. George S. Davis. An interesting account of the rapid development of electric railways in this state, giving much information concerning the different projects. Map. 13000 w. St Ry Jour—Aug. 3, 1901. No. 42551 D.

The System of the Toledo and Monroe Railway. William S. Conant. Illustrates and describes this portion of a proposed line to connect the cities of Detroit and Toledo. 3500 w. St Ry Jour—Aug. 3, 1901. No. 42549 D.

Loop.

The Interurban Railway Loop at Columbus, O. Illustrates this loop and describes its construction. 1700 w. Munic Engng—Aug., 1901. No. 42559 C.

Railway Construction.

The Use of Concrete in Railway Structures. Editorial on the varied purposes to which concrete is now applied, either alone or in combination with steel. 3800 w. Eng News—Aug. 15, 1901. No. 42690.

Roundhouses.

Roundhouse Construction and Equipment. Editorial discussion of needed improvements and best construction. 3900 w. Eng News—Aug. 22, 1901. No. 42909.

Stations.

A London Railroad Station. Illustrated detailed description of Euston station, of the London & North Western Railway. 1900 w. R R Gaz—Aug. 2, 1901. No. 42506.

New Union Passenger Station at Dayton, O. Illustrated detailed description of an exceptionally fine station. 1400 w. Eng News—Aug. 8, 1901. No. 42601.

Proposed Union Station at Troy, N. Y. A brief account of the present condition of the property, with an illustrated description of the structure proposed. 700 w. Ry Age—Aug. 23, 1901. No. 42779.

Street Railway Stations in Basle (Strassenbahnhöfe in Basel). With views and plans of several of the attractive buildings at the stations and waiting places of the street and local railways. 1500 w. Schweizerische Bauzeitung—Aug. 17, 1901. No. 42851 B.

Station Roofs.

Railway Station Roofs. Discusses and criticizes the roofs used on stations of British railways. 2700 w. Engr, Lond—Aug. 2, 1901. No. 42648 A.

Terminals.

Terminal Improvements at Savannah. An illustrated description of the recent work by the Georgia & Alabama Terminal Company, on Hutchinson Island, opposite the city of Savannah, and on the north bank of the Savannah River. 1300 w. R R Gaz—Aug. 2, 1901. No. 42509.

Tramways.

The Naples-Aversa-Caivans Interurban Electric Railway System. An illustrated description of this line and the region through which it passes. 1200 w. St Ry Jour—Aug. 3, 1901. No. 42547 D.

The System of the Atlanta Rapid Transit Company. Illustrated detailed description. 2500 w. St Ry Jour—Aug 3, 1901. No. 42546 D.

Tunnel Ventilation.

A Proposed Ventilating System for the Park Ave. Tunnel, New York City. Albert A. Cary. Illustrated description of the system proposed by the writer in his testimony before the Grand Jury while investigating this problem. Also editorial. 2300 w. Eng News—Aug. 8, 1901. No. 42606.

Union Pacific Ry.

The Rebuilt Union Pacific. An illustrated article giving information concerning the heavy engineering work that has been carried out in the recent improvements on this road, at a cost of about $15,000,000. Map. 3300 w. Ry Age—Aug. 9, 1901. No. 42662.

TRAFFIC.

Freight.

Management of Freight Trains and Freight Houses. Abstract of a paper by L. C. Fritch. Suggestions from the Supt. of the B. & O. Southwestern. 1600 w. R R Gaz—Aug. 9, 1901. No. 42611.

The Handling of Freight Traffic. L. C. Fritch. Full paper. Discusses the classification, methods, &c., offering suggestions of value. 1600 w. St Louis Ry Club—Aug. 9, 1901. No. 42959.

Graphic Records.

Graphic Records of Cars and Trains. Notes from G. F. Richardson, master of transportation on the Southern Pacific, concerning graphic methods in use. 1500 w. R R Gaz—Aug. 16, 1901. No. 42680.

MISCELLANY.

East Indies.

Increase in Capacity of the Mountain Railways in the Dutch East Indies Verhooging van de Capaciteit van Bergspoorwegen in Nederlandsch-Indië). A. Snethlage. With map of the road between Buitenzorg and Bandong, and data of the traffic. 4000 w. De Ingenieur—Aug. 3, 1901. No. 42847 D.

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THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *t-m*, a tri-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the index are: Ill—Illustrated; W—Words; Anon—Anonymous.

Alliance Industrielle. *m.* Brussels.
American Architect. *w.* Boston, U. S. A.
American Electrician. *m.* New York.
Am. Engineer and R. R. Journal. *m.* New York.
American Gas Light Journal. *w.* New York.
American Geologist. *m.* Minneapolis, U. S. A.
American Jl. of Science. *m.* New Haven, U.S.A.
American Machinist. *w.* New York.
Am. Manufacturer and Iron World. *w.* Pittsburg, U. S. A.
American Shipbuilder. *w.* New York.
Annales des Ponts et Chaussées. *m.* Paris.
Ann. d Soc. d Ing. e d Arch. Ital. *w.* Rome.
Architect. *w.* London.
Architectural Record. *q.* New York.
Architectural Review. *s-q.* Boston, U. S. A.
Architect's and Builder's Magazine. *m.* New York.
Armee und Marine. *w.* Berlin.
Australian Mining Standard. *w.* Sydney.
Autocar. *w.* Coventry, Eng.
Automobile Magazine. *m.* New York.
Automotor & Horseless Vehicle Jl. *m.* London.
Brick Builder. *m.* Boston, U. S. A.
British Architect. *w.* London.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bulletin Am. Iron and Steel Asso. *w.* Philadelphia, U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bulletin Scientifique. *m.* Liege.
Bull. Soc. Int. d Electriciens. *m.* Paris.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bull. Int. Railway Congress. *m.* Brussels.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Montreal.
Canadian Mining Review. *m.* Ottawa.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Contemporary Review. *m.* London.
Deutsche Bauzeitung. *b-w.* Berlin.
Domestic Engineering. *m.* Chicago.
Electrical Engineer. *w.* London.
Electrical Review. *w.* London.
Electrical Review. *w.* New York.
Electrical World and Engineer. *w.* New York.
Electrician. *w.* London.
Electricien. *w.* Paris.

Electricity. *w.* London.
Electricity. *w.* New York.
Electrochemist & Metallurgist. *m.* London.
Elektrizität. *b-w.* Leipzig.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricita *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Cleveland, U. S. A.
Engineers' Gazette. *m.* London.
Engineering. *w.* London.
Engineering and Mining Journal. *w.* New York.
Engineering Magazine. *m.* New York & London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Eng. Soc. of Western Penn'a. *m.* Pittsburg, U. S. A.
Fire and Water. *w.* New York.
Foundry. *m.* Cleveland.
Gas Engineers' Mag. *m.* Birmingham.
Gas World. *w.* London.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. Dei Lav. Pubb. e. d. Str. Ferr. *w.* Rome.
Glaser's Ann. f. Gewerbe & Bauwesen. *s-m.* Berlin.
Horseless Age. *m.* New York.
Ice and Refrigeration. *m.* New York.
Indian and Eastern Engineer. *m.* Calcutta.
Ingeneria. *b-m.* Buenos Ayres.
Ingenieur. *w.* Hague.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron & Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland.
Jour. Am. Foundrymen's Assoc. *m.* New York.
Journal Assn. Eng. Societies. *m.* Philadelphia, U.S.A.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Journal of Sanitary Institute. *qr.* London.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery. *b-m.* Fort Monroe, U.S.A.
Journal Western Soc. of Eng. *b-m.* Chicago.
Journal of Worcester Poly. Inst., Worcester, Mass.
Locomotive. *m.* Hartford, U. S. A.
Locomotive Engineering. *m.* New York.
Machinery. *m.* London.
Machinery. *m.* New York.
Madrid Cientifico. *t-m.* Madrid.
Marine Engineering. *m.* New York.
Marine Review. *w.* Cleveland, U. S. A.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Metal Worker. *w.* New York.
Métallurgie. *w.* Paris.
Minero Mexicano. *w.* Mexico.
Minerva. *w.* Rome.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Metallurgy. *s-m.* New York.
Mining and Sci. Press. w. San Francisco, U.S.A.
Mining Journal. *w.* London
Mining Reporter. *w.* Denver, U. S. A.
Mitt. aus d Kgl Tech. Versuchsanst. Berlin.
Mittheilungen des Vereines für die Förderung des Local und Strassenbahnwesens. m. Vienna.
Modern Machinery. *m.* Chicago.
Monatsschr. d Wurtt. Ver. f Baukunde. *m.* Stuttgart.
Moniteur Industriel. *w.* Paris.
Mouvement Maritime. *w.* Brussels.
Municipal Engineering. *m.* Indianapolis, U. S. A.
National Builder. *m.* Chicago.
Nature. *w.* London.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Nineteenth Century. *m.* London.
North American Review. *m.* New York.
Oest. Wochenschr. f. d. Oeff Baudienst. *w.* Vienna.
Oest. Zeitschr. f. Berg- & Hüttenwesen. *w.* Vienna.
Ores and Metals. *w.* Denver, U. S. A.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Power Quarterly. New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Proceedings Engineers' Club. *qr.* Philadelphia, U. S. A.
Pro. St. Louis R'way Club. *m.* St. Louis, U. S. A.
Progressive Age. *s-m.* New York.
Quarry. *m.* London.
Railroad Digest. *w.* New York.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway & Engineering Review. *w.* Chicago.
Review of Reviews. *m.* London & New York.
Revista d Obras. Pub. *w.* Madrid.
Revista Tech. ed Agr. *b-m.* Catania.
Revista Tech. Ind. *m.* Barcelona.
Revue de Mécanique. *m.* Paris.
Revue Gen. des Chemins de Fer. *m.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines. *m.* Liége.
Rivista Gen. d Ferrovie. *w.* Florence.
Rivista Marittima. *m.* Rome.
Sanitary Plumber. *s-m.* New York.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens' Institute Indicator. *qr.* Hoboken, U.S.A.
Stone. *m.* New York.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago.
Telephone Magazine. *m.* Chicago.
Telephony. *m.* Chicago.
Tijds. v h Kljk. Inst. v Ing. *qr.* Hague.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. of Civil Eng. *m.* New York.
Trans. Am. Soc. of Heat & Ven. Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Trans. Inst. of Engrs. & Shipbuilders in Scotland, Glasgow.
Transport. *w.* London.
Western Electrician. *w.* Chicago.
Wiener Bauindustrie Zeitung. *w.* Vienna.
Yacht. *w.* Paris.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochemie. *w.* Halle a. S.

IMPROVED MACHINERY

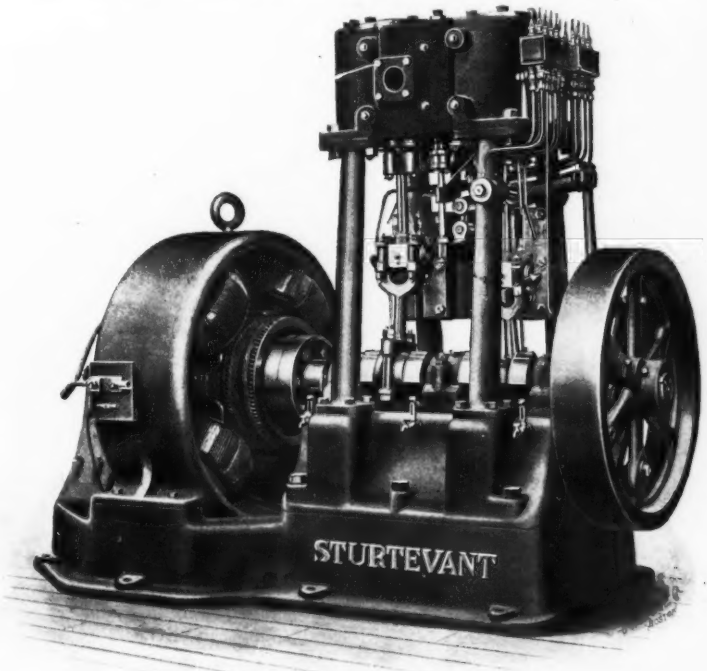
New Processes and New Appliances

The matter here published is not paid for, nor can it be classed as advertising. But as the information is necessarily obtained from those who offer the appliances for sale, it is proper to say that the manufacturers, rather than ourselves, are responsible for the statements made.

A Typical Generating Set.

DURING the past few years the B. F. Sturtevant Co., of Boston, Mass., has been making great strides in the development of its electrical department. Beginning as it did with the building of motors for direct connection to fans, it took some time to convince the public that this company was definitely in the field as builders of a special line of small high grade generating sets. This work, however, is the natural outcome of the possession of a very extensive line of engines of over 100 sizes and under 250 H. P., and of a similarly extensive line of sizes of motors designed for direct connection to fans. By simple combinations of these engines there has been produced a line of generating sets, the extent and variety of which is not approached by any other manufacturer.

In the accompanying illustration is presented one of their latest designs in a generating set with open type vertical compound engine and 4-pole generator. In this design the bed carries three main journal bearings, brass bushed in their lower halves and provided with continuous oiling devices in connection with oil reservoirs beneath; its interior is formed into a basin which collects all drip from water or oil. The four heavy upright columns are securely fastened to this bed, and to their upper ends is bolted



the single cylinder casting, comprising the two cylinders, which are of relatively large diameter and short stroke.

Two piston valves are operated in unison by a single rocker and yoke, each regulating the admission of steam to one cylinder.

The cross heads are of the slipper type with projecting cross head pins; the connecting rods have yoked cross-head pin ends and are of large size. Both connecting rods and cross heads are of forged steel and all parts of the engine are of the highest grade as regards material and workmanship. The cylinders are thoroughly lagged. Complete sight feed oiling arrangements are provided for all bearings. These engines are built in sizes 6½, 11 x 5½ and 7, 13 x 5½, with output at 150 pounds of 47.5 and 60 H. P.

The armature shaft is direct connected to the engine shaft and carries an armature of the barrel wound toothed drum type with slotted discs of carefully annealed sheet steel, which after being coated with an improved insulated varnish is mounted upon a cast iron drum. This drum is provided with longitudinal air ducts which connect in turn with radial ducts passing through the core and by means of small blades or vanes inserted in these ducts, compel the circulation of a constant current of air, thereby greatly facilitating ventilation and insuring a cool running armature.

The winding for all low voltage machines is of copper bars. High voltage or very slow speed machines have the armature wire wound with machine formed coils, which coils are thoroughly insulated before being placed upon the core. The magnet frame is of special magnet steel and has the field cores cast therewith. The ring is cast in one piece.

The commutator consists of drop forged segments of pure copper, mounted upon and secured between cast iron flanges of spider construction which allow a circulation of air inside as well as outside and conduces to low temperature.

Carbon brushes only are used in these machines and mounted in holders of the sliding socket type with easy facilities for adjustment and removal. A full load run for a sufficient length of time to bring every part to its maximum temperature has never been found to reproduce a temperature rise exceeding 40° Cent.

Reconstructed Granite.

THIS is a new insulating material, which has been extensively introduced not only in the United States, but also in Europe, during the past two years, and as it possesses some remarkable properties, a description of it will prove interesting to our readers.

As its name implies, it consists of true natural granite, pulverized, and molded into any desired forms under great pressure, and then fuzed together into a solid, homogeneous mass at a temperature of about 3,000° F. Its peculiar properties are:

1st. Its great strength, varying for crushing strains (according to its form and fineness of texture), from 10,000 to 18,000 pounds per cubic inch. Its tensile strength also is from 900 to 1,000 pounds per square inch.

2d. Its resistance to sudden changes of temperature, it being capable of being heated

red-hot, and plunged into cold water without cracking or injury. It is absolutely fireproof up to 2,800° to 3,000° F., and has been frozen in liquified air to 350° below zero without injury, and without in any way impairing its strength or toughness, even while frozen.

3d. It resists all known acids or alkalies, either hot or cold (except hydrofluoric acid, which attacks it only superficially). Vessels of this material can be used for boiling sulphuric, nitric, or hydrochloric acids, and chlorine or other gases do not affect it.

4th. Its high ohmic resistance to electrical currents, which, in combination with its other properties, renders it a peculiarly valuable insulating material for high potential work, especially where exposed to the weather and rough usage; such as third-rail

insulators, surface contact blocks, feed wire insulators, arc deflectors, etc. It has been awarded by the Franklin Institute of Philadelphia acting on behalf of the city of Philadelphia, after a series of tests extending over fifteen months, the "John Scott Legacy Medal and Premium" for high merit as an insulating material.

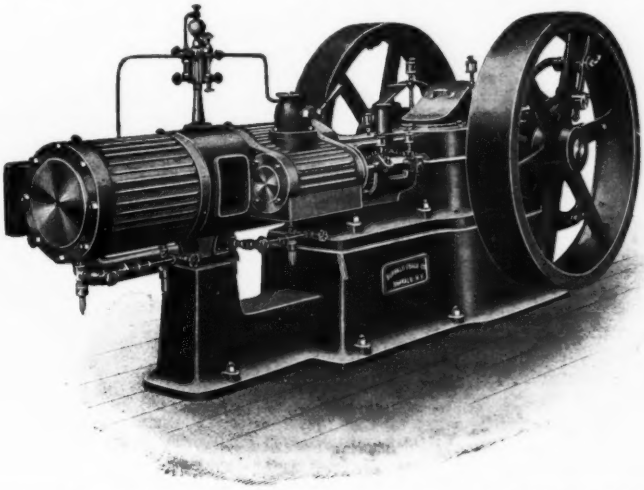
It is obvious that a material possessing such valuable properties has a wide range of application, but the manufacturers are confining their attention chiefly to the electrical field at present and are dealing with the largest electrical concerns in the United States and Europe, and find the volume of their business rapidly increasing. Among the principal articles manufactured by them are "third-rail" and feed-wire insulators, surface contact blocks, rheostats of various forms and types, and "flash-plates" or "arc deflectors" for railroads, for which last use it has the remarkable feature of instantly chilling the arc.

We illustrate one form of "third-rail" insulator, which is very simple, strong, durable, and effective, and has the additional advantage of being comparatively low in price, of which many thousands are now in use, and many more contracted for at home and abroad. This material is manufactured by the Reconstructed Granite Co., of No. 14 Dey street, New York, who have extensive works at Norristown, Pa.

Buffalo Tandem Compound Engine.

THE cut herewith presented gives a general idea of the Horizontal Tandem Compound Engine, manufactured in the Engine Department of the Buffalo Forge Company's works at Buffalo, N. Y. A short description may here suffice to render clear some of the features of this machine.

A heavy cast iron sub-base furnished a solid support to which to bolt the engine bed, and at the same time raises the engine sufficiently for the fly-wheels to clear the floor or foundations. In the case of dynamo direct connection this sub-base may also provide a bed for the generator, and in addition carry out the out-board bearing. The high pressure cylinder is placed in front, bolted at one end to the head cast to the frame. The other end is bolted to a yoke or connection between the cylinders, which also carries the overhung low pressure cylinder. The foot of this yoke rests upon a pedestal extension of the sub-base with a feather or expansion joint connecting the two. The three movable cylinder heads are so fastened to their respective cylinders as make feasible their easy detachment with the pistons and rod, if occasion requires. This, with the ready accessibility of all stuffing boxes, is a distinct merit of the Buffalo Tandem Compound Engine. The pistons are single castings cored thin, giving maximum strength with minimum



weight, and causing but little wear on the bottom of the cylinders.

The crank shaft and connecting rod are of forged steel, the latter of which is fastened to the crank-pin by means of a strap and wedge. The wedge is completely enclosed by the strap and box and is securely held by two adjusting lock bolts.

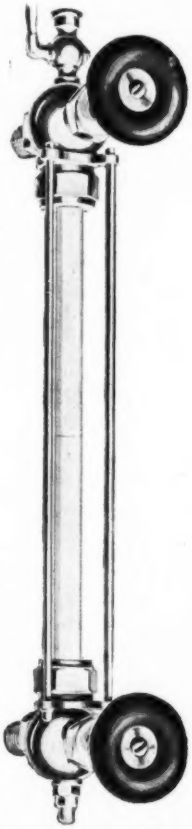
The high pressure valve is of the piston type, while the low pressure end is fitted with a balanced "D" slide valve with a pressure plate. The former valve is under the control of shaft governor, while the low pressure valve may also be driven by the swinging eccentric, or, according to an alternative construction, by a fixed eccentric, so arranged as to permit alteration of the cut-off at all times. This arrangement is effected by means of bolting the eccentric sheave in such a manner as to permit change of throw and angular advance, and hence cut-off at pleasure. The fly-wheel governor for the high pressure side is of the most sensitive type. It is provided with three means of adjustment, so that it may be accurately set to control the engine at any given speed; in addition grease or oil cups are provided on every pin.

This engine is enclosed to run in oil, and a positive means of lubrication is thereby furnished for the main bearings crank-pin, wrist-pin, and crosshead slides. An ample supply of oil for the wrist-pin is insured in the Buffalo engine by a cup on the pin, which is filled continuously with oil thrown back from the crank discs, and communicates with the rubbing surfaces. Pockets or receptacles located within the bed near the crank discs are kept filled with oil while the engine is in motion, and feed the necessary amount of lubricant to the main bearings. Provision is made for returning the oil to the crank-pit after it has been supplied to the various rubbing surfaces. A light polished hood and two side plates give a perfectly oil-tight construction, and being easily removable, afford ready accessibility to the various moving parts. A large sight feed lubricator takes care of the cylinders and valve chests. The very best babbitt metal is used throughout this engine at all bearing surfaces, and adequate means are provided for adjustment and taking up of wear.

This Tandem Compound Engine, combining as it does close regulation and efficient lubrication, presents many valuable points, adapting it for lighting and general power service. The direct connected unit with Tandem Compound Engines is especially advantageous. The efforts made of late to attain greater economy in the use of steam has resulted in a rapidly increasing demand for compound engines, and the machine we here illustrate and describe is a product of this demand.

Durax Gauge Glasses.

THE Jena compound (Verbundglass) gauge glasses, introduced into this country some years ago by Schaffer & Budenberg, Brooklyn, N. Y., have been a great success and proved to be of far better quality than any other glasses made heretofore for the same purpose.



Since then a new composition of glass has been invented by the manufacturers of these glasses which has proved to be even superior to the "Compound Glass." These glasses will be known under the name of Durax Glasses. They have a light blue stripe as trade mark, which distinguishes them from any other gauge glasses in the market.

Extensive comparative trials with these glasses as to resistance against sudden changes of temperature and drops of cold water blown against them have given the following results:

TABLE A.

Resistance. Glasses broke:

French glasses at 6 Atm.=90 lbs.; English or Scotch at 7 Atm.=105 lbs.; Verbund Glasses at 15 Atm.=225 lbs.; Durax Glasses at 27 Atm.=405 lbs.

The following, Table B, shows the loss in weight by the action of steam and water during a period of fifty hours under exactly the same conditions.

TABLE B.

Loss in weight by wear:

French Glasses, 5.8 200; English or Scotch Glasses, 8.84 303; Verbund Glasses, exterior tube, 2.92 100; Durax Glasses, 1.32 38. In milligram per sq. ctr. surface, in proportion to 100 of Verbundglass.

These tables prove the respective strength of the Durax glasses to be from four to six times greater than the French and English or Scotch glasses, and that they have such advantage over the "compound glasses" (Verbundglasses) as to justify their use in preference, the small increase in price being fully compensated by their higher quality.

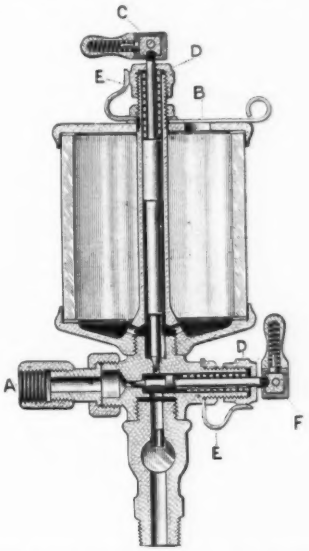
The Durax glasses can therefore be highly recommended for use on all boilers, and especially on locomotives, automobiles, traction engines, and on boilers exposed to the weather and sudden change of atmospheric temperatures.

Pressure Oil Cup.

THE pattern of pressure oil cup shown herewith contains a number of improvements over all forms of cups heretofore used on pressure oiling systems. In all other makes of cups the glass cylinder or reservoir must constantly be kept under pressure, and, in case of breakage of same, considerable oil is lost and the cup is rendered useless. Another bad feature of the old style of construction is that, on account of the large diameter of the glass cylinder, if the pressure on the oil supply is anyways considerable, it is difficult to keep the joints from leaking.

In the new form of cup, shown above, the glass reservoir is not under any pressure whatever, but, instead, the oil supply is piped through the union (A) in base, the opening of which into the oil duct leading to the bearing is controlled by oil regulating valve (F). The auxiliary supply is regulated by the oil valve (C).

The advantages of this construction in pressure oil cups are obvious in comparison made with other styles. With this improved cup it is always easy to regulate the supply of oil under pressure, and, when it is desirable to cut off same, the valve (F) can be



turned down and will act as an indicator, showing from a distance that the supply is shut off. The regulation of this valve is very simple and easily affected, and, when once set, is not disturbed by the jarring of the machinery. The feed can be turned on or off by simply raising or lowering the cam lever (F). The sight-feed in the base is large, and the falling drops of oil can be seen plainly from a distance. The auxiliary oiler (which is intended to be used in case the pressure should be discontinued or cut off) consists of our standard pattern "Sentinel" oil cup, the feeding of oil being regulated by the cam lever (C) in the same manner as with the pressure supply. The axuiliary oiler has a large slide filler (B) which dispenses with the screw plugs used in other patterns.

All parts about this cup are made of cast —not spun—brass. It is a heavy, substan-

tial, and durable device, simple in operation, and practical in its applications. Manufactured by the Lunkenheimer Co., Cincinnati, Ohio.

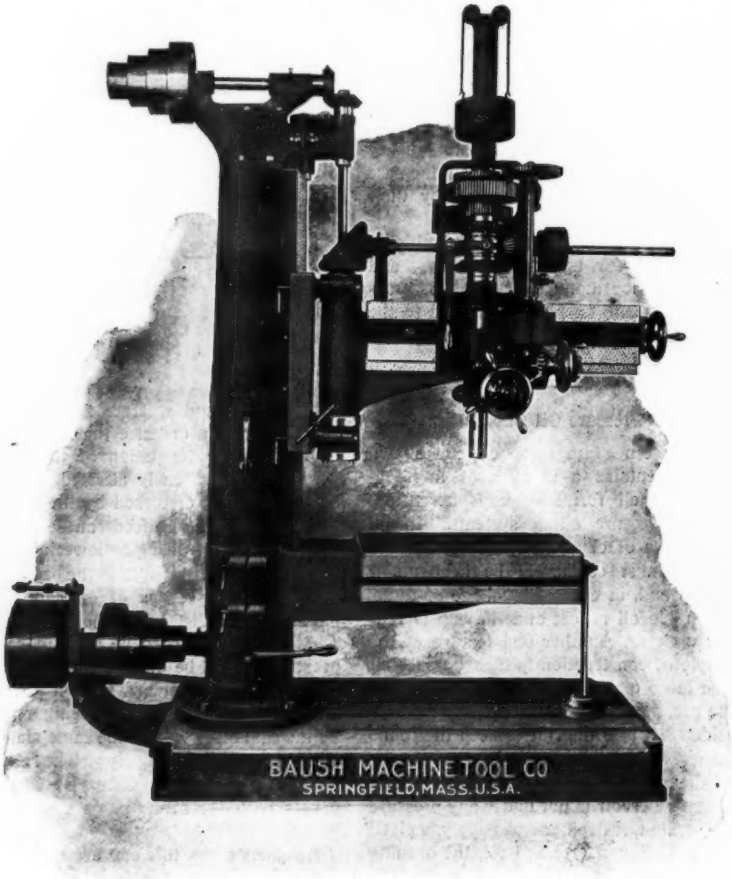
A New Tool.

THE accompanying cut shows one of the new machine tools recently brought out by the Baush Machine Tool Co., of Springfield, Mass.

It is a tool that demonstrates the advances which modern demands are making over old methods, as it is made to take the place of the regular upright drill with the added advantages of the radial arm and the tapping attachments, which, later being embodied as a part of the machine, can be operated without any delay for attachment, etc.

The table swings on the post, and can be swung out of the way, if work is too large or heavy for the table, as the saddle carrying the arm moves up and down on the post, it is not necessary to raise or lower the table.

Gear driven throughout with the back gears on the spindle, it makes it very positive and rigid, the gears being covered to avoid danger to the operator. Doing away with the countershaft, is another feature worthy of mention, as it does not require the wooden lever with its cumbersome looks, bother, and rattle.



It is self containing and does not need a special foundation, any solid floor being sufficient for it.

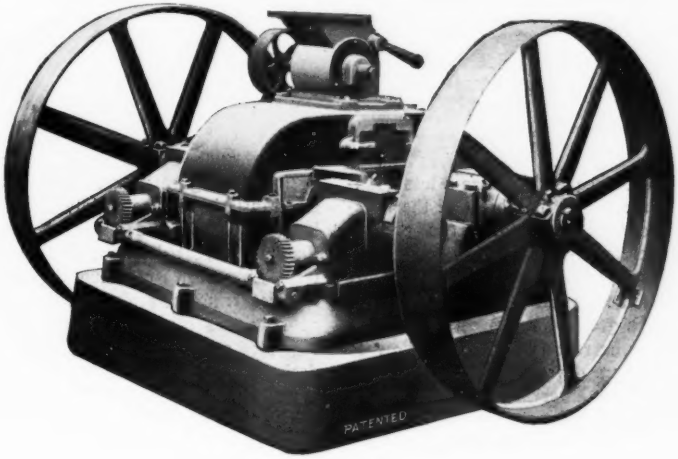
The general dimensions are as follows: Will drill in the center of an 82-inch circle; bed, 89 inches long, 32 inches wide, 6½ inches thick; extreme height with arm and spindle up, 114 inches; the greatest distance from spindle to bed, 48 inches; to table, 24 inches; driving belt on cones, 3¼ inches; spindle, made of tool steel with No. 4 Morse taper, 2½ inches; largest diameter, 12 inches traverses, counter balanced with quick return; arm supported on roller and ball bearings, with locking devices; swinging table, 18 inches by 30 inches by 6 inches finished surface; weight, 4,200 pounds.

Centrifugal Spring Rolls.

THE accompanying illustration shows in perspective a set of centrifugal spring rolls, manufactured by the Sturtevant Mill Co., of Boston, Mass. A peculiarity of the centrifugal spring rolls is that they can be run at any number of revolutions according to the requirements of peculiar conditions in hand. To each of the weights in the plain centrifugal roll has been added a set of powerful springs, which constantly press the weights outward and hold the tire, even when the roll is at rest, with a force equalling the pressures given to common rolls by their outside springs. Centrifugal spring rolls, therefore, exert at the slowest speeds at least common roll pressures. As in plain centrifugals neither roll, shaft, or bearing moves at all. It will be seen from this that they run without any of the tremendous shocks accompanying common rolls and they speed as steadily as other centrifugals. It is clear that as soon as spring rolls begin to run at all, the centrifugal forces generated add to the spring pressures and an enormous crushing power is attained. This roll offers ideal conditions, in that its speed can be suited to any ore, thus obtaining the highest possible working economy. The illustration shows a 32-inch centrifugal roll, the largest size made.

Electric Current Regulator.

IN the practical utilization of electricity in connection with various translating devices it is common to provide a main or lead circuit carrying a current of constant potential or voltage and to include the translating devices in that lead or main line, so that they will take the current therefrom and the quantity of amperes of current used will depend upon the character and use made of the translating devices. In connection with various forms of translating devices it is often desirable to utilize less than the normal or maximum quantity of current necessary to energize said translating devices to their full



operative condition. For instance in the use of lights, heaters or motors included in the circuit, and which under normal conditions require a certain quantity of current to operate the motor at a given speed or power, to energize the heater to produce a certain degree of heat or the lamp to produce a certain amount of illumination, a constant flow of current of a certain volume or quantity is required. It is often found desirable to energize such translating devices to a point below the normal or full degree of energy, so as, for instance, to produce a less degree of illumination, heat or power and consequently utilize a less quantity of current, and the object of the rheocrat or current regulator is to provide means whereby this may readily be done.

This is accomplished, broadly stated, by cutting off the current from the translating device for a greater or less period of time, so that the current is allowed to flow to the translating device at relatively short intervals, which intervals, however, follow each other in rapid succession sufficient to produce the desired effects. Thus for instance, ordinarily when a motor, heater, light, or similar translating device is included in the circuit and it is desired to reduce the quantity of the current below the normal or less than the full degree of energy, resistance devices are interposed in the circuit of the translating devices and the current continues to flow through the resistance devices and translating devices, while the effect of the current on the translating devices is below that where the whole current flows directly and continuously through the translating devices.

The rheocrat or current regulator instead of introducing resistance in the circuit of the translating device rapidly cuts the translating device in and out of the circuit, so that the current does not flow through the translating device continuously, but at rapidly recurring intervals, and these intervals of flow and stoppage of the current are regulated and adjusted so as to produce the desired effect in the translating device without any waste of energy.

The absolute control of the current by the rheocrat differs from all rheostats generally

and universally used for the same purpose. Rheostats always consume the proportion of energy taken from the circuit going to the translating devices and all they consume is absolutely wasted, as it serves no useful purpose.

To illustrate, if it is desired to reduce the energy consumed by an apparatus to one-fourth, when this is done by a rheostat the amount of energy taken from the circuit is only reduced to one-half. Half of this is consumed in the rheostat which is thereby heated. With the rheocrat only so much energy is taken from the circuit as is usefully used, and there is no heating of the regulating device.

When a certain number of translating devices, for example, lights (or any other apparatus) are in circuit, and a larger number of lights are added to this circuit, the rheostat must be re-adjusted for every different number of lamps it is called upon to supply, if the brilliancy of the lamps is to remain the same, while the number in circuit is changed. The rheocrat absolutely controls the circuit in all cases without re-adjustment, no matter how many lights, motors, heaters or other translating devices are switched in or out on the same circuit.

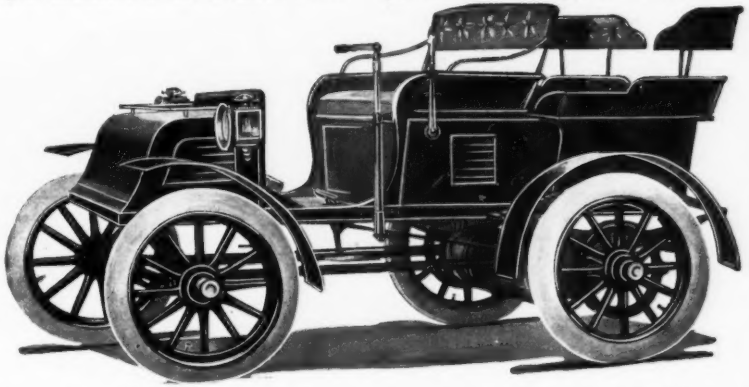
This absolute control of the current by the rheocrat without waste of energy, applies to charging of storage bateries, etc., or the regulating of the current wherever desired.

Further particulars with regard to this device will be furnished by the Erie Exploration Company, 30 Broad street, New York.

Columbia Electric Tonneau.

THE production of this type of vehicle marks an important development in American automobile manufacture. It disposes of the criticism of the electric automobile (that as a carriage it appears to need a horse) as no vehicle has as yet done. The body is designed on lines which have found most favor among the gasolene types abroad and the merchanical construction presents features novel in an electric vehicle.

As a standard type it is furnished with an operator's seat, comfortably accommodating two passengers, and a tonneau body with accommodations for two additional passengers. The tonneau body is removable and in its place may be substituted either a surrey seat, accommodating two passengers, or a rumble seat, for an attendant, or a hamper for light luggage; if desired the rear space may be left vacant to hold heavy luggage.



This vehicle has a double motor equipment. The controller handle and steering rod are on the left-hand side, leaving a clear space in front of the operator's seat. The controller gives three speeds ahead and two backwards. Several marked advantages result from the arrangement of the battery. It is carried on both the front and rear axles, equalizing the weight, and largely increasing its hill climbing capabilities.

The four wheels are of the same size and the body hangs low. All these features add greatly to the comfort and pleasure of the occupants.

Side lamps, electric alarm gong, fenders

and water-proof aprons are provided as standard equipments. There is a compartment especially designed or the carrying of tools, a full complement of which is provided. Further details may be had from the Electric Vehicle Co., New York.

Shop Lockers.

In view of the improvements recently made in caring for the belongings of employees while they are at work, it is interesting to note the style of lockers installed by the British Thomson-Houston Co.

The lockers are of the single tier type, the center of the door to keep out dust and hide the contents of the lockers. The inclined top prevents articles being stowed on the lockers.

The lockers are built in double rows, back to back, with doors on each side. Each double row or cabinet contains 14 to 2[illegible] lockers. The cabinets are placed about 10 feet apart with one end against the wall, thus forming dressing rooms 10 feet wide and the length of the cabinet of lockers.

Every department has a separate locker room, that of the machine shop being 31 feet wide and 142 feet long, and holding 420 lockers.

15 inches wide, 15 inches deep and 5 feet high, with an inclined top and raised base. Each locker has a shelf for a hat, lunch box, etc., and four hooks for clothing. The bottoms are galvanized iron, arranged to conduct any water from wet umbrellas or dirt from overshoes to the back of the lockers or to the center of the cabinet, where it may fall to the floor or into a long pan. The feet raise the lockers so that they may be easily swept under.

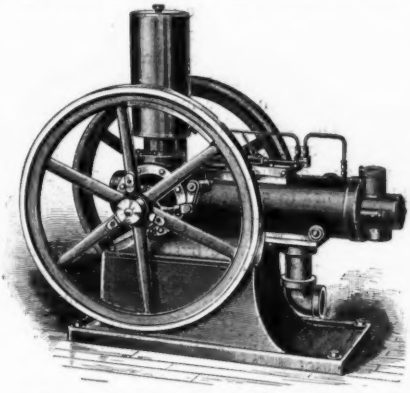
Ventilation is secured by grates in the tops and bottoms of the doors, thus leaving

The lockers were made by the Narragansett Machine Co., of Providence, R. I., who have for several years made a specialty of this work. This company is perfecting a steel locker that will embody the features they have found by experience to be valuable.

Kerosene Gas Engines.

The accompanying cut shows a kerosene engine made by A. Mietz, 128-138 Mott street, New York City. A gas engine has

a great many advantages, but the field of its application is of necessity somewhat restricted, as it must be used where there is a gas supply. The usefulness of a kerosene engine has recently been greatly extended, as it is now possible to obtain the fuel in almost any locality and to transport it to any locality where any other variety of fuel can be taken. The working of gas and kerosene engines is the same, the only difference being in the mechanism for injecting the fuel into the cylinder. The Mietz engine receives at full power an impulse at each turn of the crank-shaft. The compression and burning of the mixture, and the expulsion of the exhaust, are all performed at a single turn in a direct and simple manner. The



engine is dust-proof and the enclosure of the crank-shaft, the absence of cams, valves, and side shafts, obviates all danger to inexperienced attendants. The crank-shaft bearings are rigid, the engine is thoroughly lubricated, and it is said to have no odor whatever about it. The ignition of this engine is effected by compression and is automatic. The fuel supply is enclosed in a closed copper tank or oil receiver, which is firmly screwed to the cylinder, and it has a capacity for a ten-hour run. From this tank, the oil is forced by a pump directly into the cylinder and there vaporized and mixed with the air for combustion. The kerosene engine consumes 1 pint of kerosene per H. P. hour. Small engines use more fuel per H. P. than large ones. The company reports an engine in actual operation at which cost is said to be less than one-half cent per H. P. hour.

These kerosene engines are particularly adapted for mining work on account of the portability of the engine and also of the fuel. No engineer or fireman is required. There are no ashes to be removed and no dirt about the engine. The engine can be started and managed by any person of ordinary intelligence, and since it is automatically lubricated, it requires a minimum of attention.

A Correction.

We regret that on account of haste in making up the proof for the article entitled "Mechanical and Electrical Features of the Pan-American Exposition" in our September number, we failed to notice that the statement made in the first line of the paragraph at the foot of page 853 gave a false impression in regard to the origin of the multiple voltage system.

From the way the sentence reads one would gain the impression that the Bullock Company was the originator of this system. It is well understood by electrical experts that this is not so, and that more than one electrical manufacturer has been instrumental in developing this simple method of motor control.

It is only fair to the Crocker-Wheeler Company to mention here that this system has been given special attention by their chief engineer, Mr. Gano S. Dunn, and that by Mr. Dunn's efforts, coupled with the progressive policy of the company, this multiple voltage system has been worked up to a point where there is no longer a doubt as to its being thoroughly practicable and useful. One of the first plants to be equipped with this system was Sir Joseph Causton & Sons' printing plant at Leeds, England, and although some seventy odd motors were installed by the Crocker-Wheeler Company, on multiple voltage system, some three years ago, the plant has operated without difficulty of any kind, and its showing most economical results.

The Crocker-Wheeler Company has recently installed this same system in the Richmond Locomotive Works at Richmond, Va., the Trigg Company's plant at Richmond, Va., and is now about to install a large number of motors for the machine shop equipment on the multiple voltage system in the shops of the Lake Shore &

Michigan Southern Railway Company at Cleveland.

Burglar Detector.

THE recent robbing of the vault of the Selby Smelting Co. at Crockett, Cal., points out the fact that it is necessary to have every protection possible to prevent the removal of valuable material by thieves. Burglar alarms and other electrical devices, together with the improved locks of to-day, have lessened the attempts to enter a vault by the ordinary method of entrance, and burglars have been obliged to pursue a different course. It is very evident that to enter a vault in any way except by the door must take a large amount of patient work, all of which must be done in night and must be accompanied with more or less sound. While this sound may not be discernible to the human ear, it cannot escape the microphone, which is capable of transmitting the sound of a fly walking on a board.

Had the Selby Co.'s vault been equipped with a microphone attachment, the drilling of the floor could have easily been detected by the watchman, who should listen at the receiver at certain intervals through the night, the act being recorded on a dial.

The Ericsson transmitter is admirably adapted for the purpose, on account of its extreme sensitiveness and immunity from packing. Many transmitters will work when used frequently, as this serves to agitate the carbon granules, but very few will work after having stood a long time in absolute stillness without first being shaken slightly. This fact leaves the Ericsson in a field by itself for this class of work and combined with the receiver and other apparatus of equal merit makes an equipment that can be thoroughly relied on in every instance. Further information concerning this apparatus or anything else in the telephone line can be obtained by writing to the office of the Ericsson Telephone Co., 296 Broadway, New York City.

Industrial Notes.

CHAS. A. SCHIEREN & Co., New York, have recently made an arrangement with the Imperial Leather Preserver Manufacturing Company, of Philadelphia, whereby they have acquired the sole agency for the sale of leatherine, Imperial Leather Preserver, and Waterproof Dressing. This is unquestionably the best preparation in the market for the purposes for which it is intended, namely, to dress, fill and preserve oak tanned leather belting. It makes belting very pliable without reducing the tone of the leather. It makes it absolutely weatherproof, as well as proof against many injurious substances, such as acids, alkalies, moisture, heat, etc., to which belting is frequently exposed. The merits of leatherine are well known and the material is in use by fully 6,000 of the leading manufacturers in the country.

It is safe to say that the year 1901 will show a larger number of steel propeller wheels having been made up than the total for any two previous years. The Marine Iron Works, Chicago, alone have more than doubled any previous year's sales on these steel wheels, with three months yet to hear from. The composition, being an open hearth homogeneous steel, is exceedingly tough and ductile. The sizes range from thirty inches to 5 feet in diameter.

The American Blower Co., of Detroit, is doing a very extensive business in the line of mechanical draft. Among other large orders recently received are those from the New Amsterdam Gas Co., Ravenswood, L. I., and the Wilkes-Barre (Pa.) Heat, Light & Motor Co. Each of these outfits embraces two 180 inch steel plate fans with suitable direct connected engines. Catalog No. 118 issued by this company deals with the subject of mechanical draft in a very comprehensive manner.

On account of the fact that the space devoted to floor molding has been entirely inadequate to the demands of the business, and in order to relieve the works at Canal and Judd streets of some of the heavy work, Crane Co., Chicago, has this summer erected at its works at Jefferson, Van Buren and Desplaines streets, a foundry which is to be devoted exclusively to very heavy work, *i. e.*, flanged fittings and large valves. It is a one-story brick building with a slate roof, and is equipped with two cupolas, an electric traveling crane, and every other modern convenience. This new foundry will increase Crane Co.'s capacity for very heavy work about 50 per cent.